SULPHUR

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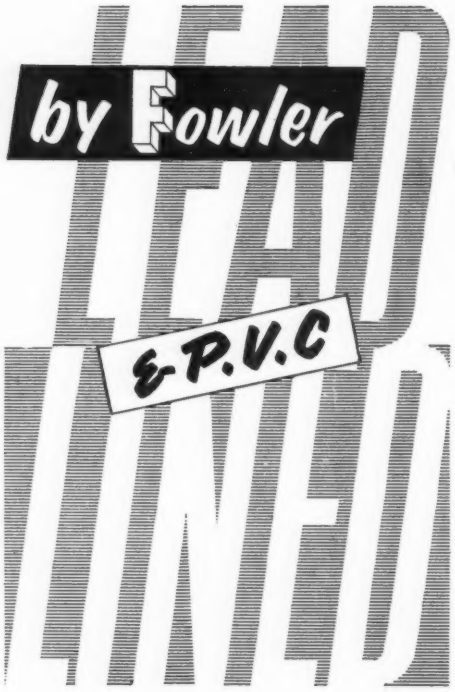

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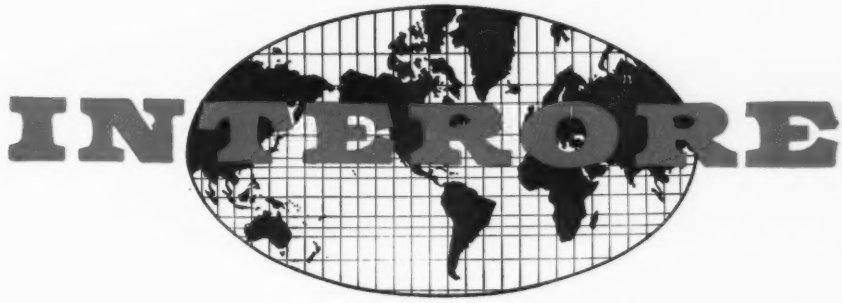

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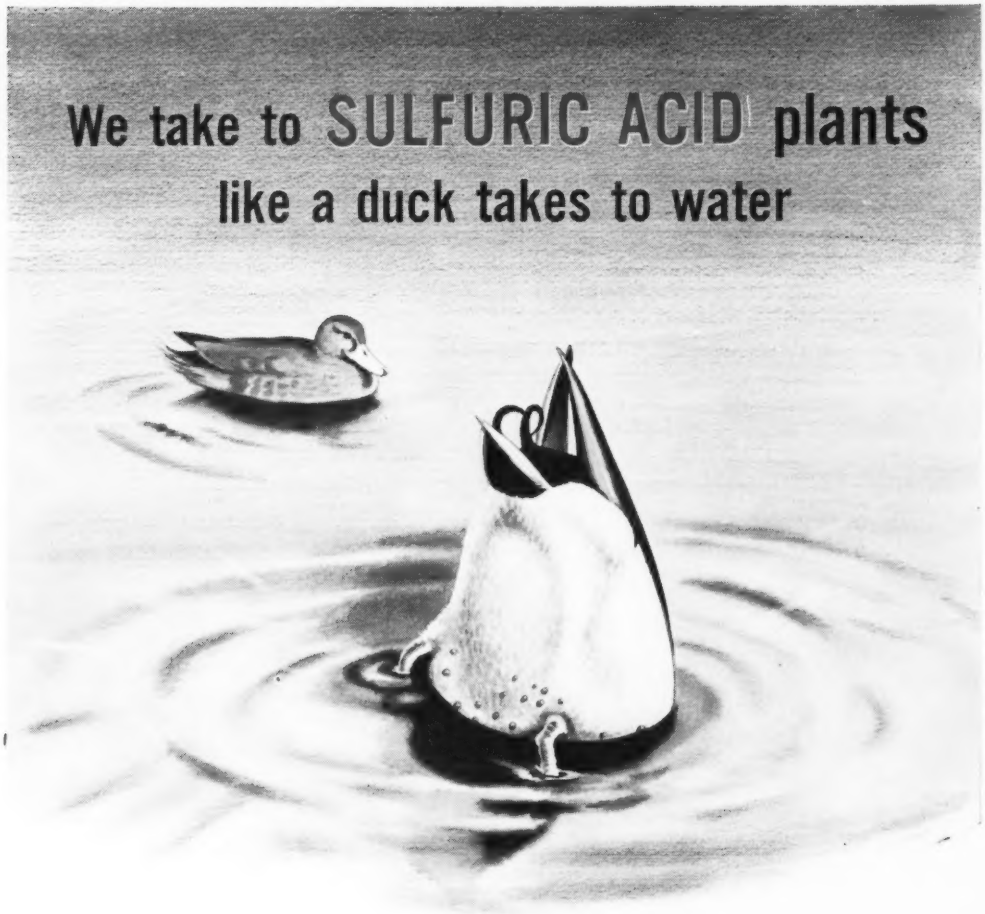

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Apology

WE offer our very sincere apologies to subscribers for an unavoidable delay in getting this issue into your hands. A seven weeks dispute in the Printing Industry of this country held up all magazine and book production and has resulted in this issue of "SULPHUR" being four weeks late. We greatly regret any inconvenience that this may have caused.

Review

World prices of sulphur have remained substantially unchanged, but the attempts to stabilize the price levels of brimstone in the main centres of competition—in the Eastern U.S.A. and W. Europe—have for the time being failed. The posted price basis remained $25 per ton f.o.b./f.a.s. for U.S. bright sulphur but in competitive markets quotations are on a "delivered" basis. European pyrites are quoted from 57s. 6d. to 67s. 6d. per tonne f.o.b. Ocean freight continues declining.

World supply is statistically firmer, as U.S. Frasch sulphur production remains low and increased demand is met from stocks. Production of Mexican Frasch sulphur and recovered sulphur especially in the U.S.A. and France is rising. World brimstone stocks are now 5.1 million tons and consumer stocks are low.

The promotion of new uses of sulphur has become imperative as, despite good statistical prospects, the rate of growth of consumption—average 3.7% over the past 50 years—is suspect because of changing conditions in the principal sulphur using industries. The recently founded Sulphur Institute is to conduct research into and develop new uses for which there is a potential use in agriculture, metallurgy, plastics and energy.

Brimstone production in Western Canada is expected to rise to 300,000 tons in 1959. By the formation of a National Energy Board natural gas exports to the U.S.A. can be expected soon resulting in increased tonnages of sulphur being recovered.

In the United States Frasch sulphur production during the first six months of 1959 was restricted while demand stimulated by exceptional fertlizer deliveries and high industrial activity caused sulphuric acid output to reach a yearly rate of 18 million short tons.

In Mexico the sulphur industry is poised for a new advance. Pan American Sulphur Company's increased level of activity, mainly as the result of the start of the new Texistipec dome, and output is now at a rate of 1½ million tons. Exports and domestic deliveries are rising.

In the United Kingdom, in the first six months of 1959 sulphur consumption rose to peak levels as the result of greater industrial activity. Completion of the sulphuric acid plant projects raises installed capacity to 2.9 million tons (100% H_2SO_4) of which 81% was employed. Demand was met by higher indigenous supplies notably anhydrite and brimstone imports.

Recovery of Carbon Disulphide by Courtaulds at the Greenfield plant in North Wales will save 8,000 tons sulphur annually. The novel plant and process is likely to find wider application at home and abroad.

The Italian Sulphur Industry, unable to compete in world markets has reduced its output of fused sulphur to 120,000 tons per annum but is increasing its supply of sulphur ores to the sulphuric acid industry.

The Sulphuric Acid Industry in India is expanding under the stimulus of growing demand for phosphatic fertilizers, textiles and chemicals. Output of 227,000 tons (100% H_2SO_4) in 1958 is to rise to 600,000 tons by 1961.

The Sulphuric Acid Bounty in Australia has been reviewed by the Government in the light of lower prices and abundant supplies.

The Sulphuric Acid Industry in Japan suffered a setback in 1958 reflecting lower demand from textile and chemical industries. Output totalled 3.8 million tons (100% H_2SO_4) still the third largest in the world.

The Humboldt Pyrites Furnace with heat recovery provides a means of recovering the exothermic heat of combustion whilst yielding an acceptable residue from arsenical pyrites. Its advent enhances the economics of pyrites use.

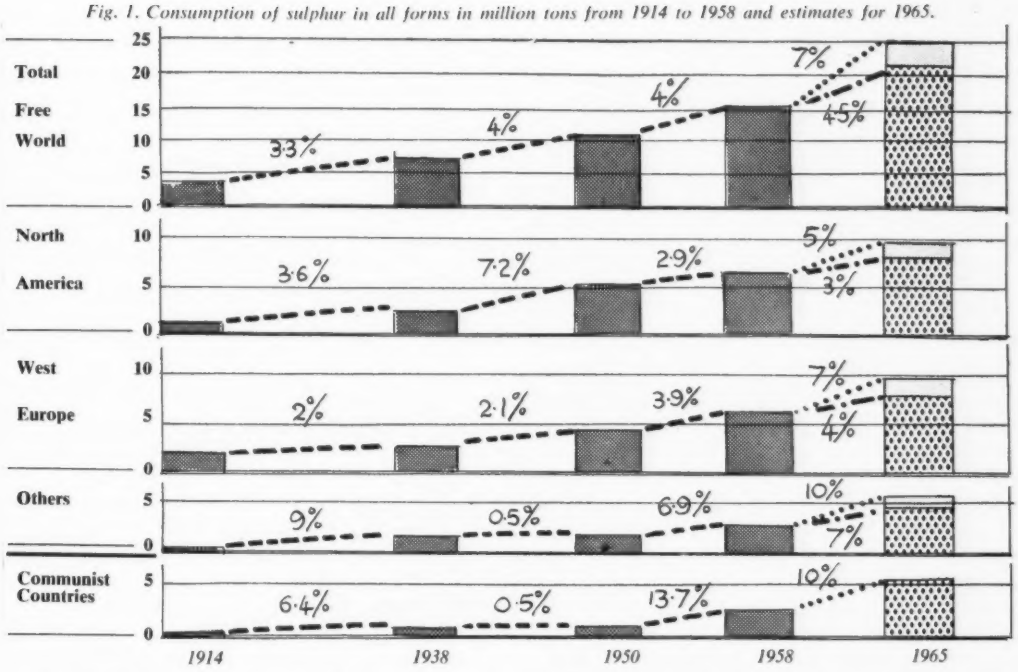
Development of New Sulphur Uses

PROBABLY THE MOST CONTROVERSIAL TOPIC in the sulphur industry to-day is the anticipated rate of growth of world sulphur demand over the next 15 years. By any of the accepted methods of statistical analysis and extrapolation a long-term trend of continued—if not faster—growth can be shown clearly, and although sulphur, or perhaps more significantly sulphuric acid which represents about four-fifths of the current level of use in the Free World, is linked predominantly with specific major consuming industries such as fertilizers, textiles or metallurgy, the constantly quoted correlation between the level of industrial activity as a whole and that of sulphuric acid remains one of the statistical phenomena. The long-term trend of expansion of sulphur consumption in the Free World over the past 50 years has been established at 3.4% per annum or, if Communist countries were included fractionally more. As the base year is advanced the growth factor—giving expression to the rapid expansion in the U.S.A. during and immediately after World War II and to the post-war reconstruction and development period in Europe—becomes greater. Thus based on 1938, consumption has increased by 4% per annum whereas based on 1948 the growth factor rises to about 5½%, and with the exception of the recession in 1952 and 1958 the short-term rates of growth are even higher as indicated by a comparison of 1952 and 1954 when the rate was nearly 6¼% per annum, or between 1954 and 1957 when it exceeded 5½% per annum.

In contrast with this statistical prospect of progressive expansion are pointers in several major sulphur consuming industries from which adverse trends can be inferred, not so much on account of recession of existing sulphur and acid uses, but rather because the tenor of expansion of recent years may not be maintained. Thus in the fertilizer industry the more rapid expansion is to be seen of ammonium nitrates and urea and of complex materials, in textiles there is the fierce impact of fully synthetic fibres; in the chemicals sector the focus is on organics, notably petrochemicals; the development of pigments and syndets—the major growth industries amongst acid users in recent years—has been checked; and when the uranium ore leaching is discounted there is at present no major new use of sulphuric acid. A possible explanation for this apparent change of an accepted trend is thought to be in the state of the sulphur industry as a whole and the Frasch sulphur industry in particular, in the period leading up to the sulphur crisis and the crisis itself. The earlier abundance of low cost sulphur supplies stimulated research into new products and processes in which sulphur or sulphuric acid played a part. It is surely more than coincidental that pre-war and war-time developments of products such as viscose rayon, titanium pigments, alkylation, etc., led to the plans for large-scale industrial operation reaching a peak in the mid-fifties. The much publicised sulphur shortage on the other hand caused many industries to restrict, if only temporarily, the use of sulphur and sulphuric acid and to seek substitutes and, what probably had a more far reaching impact, to develop products in which sulphur played a lesser rôle. The effects of this period of research is now beginning to make itself felt and the next three to five-year period could well be one in which the level of sulphur consumption was just maintained by virtue of demand from established users, but which for the first time failed to keep in step with industrial progress.

It is perhaps the height of irony that the same sulphur crisis set in train the biggest expansion programme of productive capacity ever attempted within the industry and also stimulated the intensive application of recovery processes partly in the fuel industries, especially in oil refining and natural gas cleaning, but also in processing industries such as titanium

Fig. 1. Consumption of sulphur in all forms in million tons from 1914 to 1958 and estimates for 1965.



pigments, carbon disulphide and viscose, steel and pulp, where the growing practice of recovery reduces net sulphur requirements. It is estimated that world brimstone capacity at the start of 1959—not including about ½ million tons produced in the U.S.S.R., China and East European Communist Countries — totalled about 12 million tons, of which only about 60% was employed. By 1962 some 1½ million tons new Frasch sulphur capacity and about 3½ million tons recovered sulphur capacity is due to become available whilst it is estimated that net growth of demand will have been restricted by various means of recovery by at least ½ million tons per annum sulphur. In the pyrites sector of the industry over-capacity—if availability of by-product pyrites and pyrrhotite tailings, especially in Canada and the U.S.A., are excluded—is probably less marked and the employment of mining, crushing and transportation equipment is not less than 80%, although for Spain, mainly because of the ability to increase production substantially at the Rio Tinto and Tharsis mines the ratio of employment is probably 65%.

There is little doubt that the disparity between the two trends and their likely impact on the entire sulphur industry decided the major producers of brimstone and pyrites to give effect to proposals which have been put forward from many quarters during the past two to three years.

The Sulphur Institute

At a meeting on 22nd May 1958 in Paris following several months' preparatory work, for which Mr. C. T. Hill, the Chairman of the Sulphur Export Corporation, was mainly responsible, agreement was reached amongst 23 major producing companies to form a Sulphur Institute, the overriding purpose of which is to promote the greater use of sulphur. Specifically this is to be achieved by :—

1. Technical research and development work of new processes based on sulphur or sulphuric acid.
2. Establishment of standards and specifications for sulphur.
3. Examination of economic trends in the industry.
4. Supply and dissemination of technical information.

From the top executives of the companies present a steering committee was formed consisting of :—

General A. Blanchard	Société Nationale Pétrole d'Aquitaine
Mr. J. N. V. Duncan	Rio Tinto Company Limited
Mr. O. Herneryd	Bolidens Gruvaktiebolag
Mr. C. Stevens	Texas Gulf Sulphur Co.
Mr. H. C. Webb	Pan American Sulphur Co.
Mr. C. H. Wight	Freeport Sulphur Company

The Committee's function is to draw up a charter, which it is believed will be based essentially on that of the American Petroleum Institute, to determine by-laws and to make recommendations for a 15-man Board of Directors and senior executive staff. The Institute is expected to have its administrative Headquarters in the U.S.A. and executive offices and research departments in Europe. Its finances are to be provided in the customary manner by a levy on production which has been proposed at the rate of U.S. cents 5 per ton of brimstone and U.S. cents 3 per ton of pyrites. The first statutory meeting of the Institute is expected to be held in October, thereby inaugurating a forum for regular contacts between the various sectors, the present lack of which is one of the great weaknesses of the sulphur industry.

New uses

Uncertainties of expansion of sulphur demand from established uses make it all the more important that sulphur should enter new fields. Now that its abundant and cheap supply can be seen to be assured for many years ahead, positive research programmes can be expected to come up with any number of novel uses. The following is merely an attempt at pointing in what directions research might turn.

Agriculture

The essential presence of sulphur in the soil is recognised and with the exception of a few locations, such as excessively alkaline soils of California or some cotton growing areas where the loss of soil sulphur is exceptionally heavy, the addition of sulphate sulphur in superphosphate, ammonium sulphate and sometimes even gypsum, is adequate especially as it is supplemented by precipitation which brings down, mostly as sulphurous acid, SO_2 exhausted to atmosphere in flue gases. The latter source is not likely to vanish for the time being; if anything it may increase as the sulphur content of fuel oil in use tends to be higher than coal. On the other hand, the increase in plant nutrient per ton of fertilizers and the more intensive cropping could necessitate, apart from gypsum application, the use of ground sulphur on a scale adequate not merely to compensate for deficiency in the soil but to improve the soil conditions to obtain optimum fertility. Within this sector of research we might also place the application of sulphur or, what is probably of greater importance, that of sulphur compounds and notably those with phosphorous in combating insect and fungal pests. This line of approach represents a strong alternative in the quest for providing more food for the growing world populations instead of greater fertilizer application. The means of combining the fertilizer effects of sulphur or sulphur products in the soil in conjunction with other plant food, possibly in slowly soluble form with sulphur's pesticidal properties, is an important field for examination.

Synthetic Resins and Elastomers

Hitherto the development of plastics has represented, with the exception of the modest tonnage of sulphuric acid so used, a serious restriction to the outlet of sulphur, since plastics are superseding products in the manufacture of which sulphur was substantially used. Increasingly, however, research indicates the merits of tailoring physical properties to meet specific requirements, and sulphur derivatives may thus come into their own in the plastics field. There is evidence that sulphonation will become a process of increasing importance in this field of synthetic resins and elastomers. Major progress should be achieved when sulphur compounds instead of being used only in polymerisation find application as raw materials. Some research already indicates that relatively easy re-activity of thio-urea, thio-aldehydes, thio-urethanes, thio-phenoles, etc., favours their use in place of the sulphur-free compounds in building new plastics.

Metallurgy

In this field probably more than any other has the sulphur crisis acted as serious brake. The depletion of high-grade metallic ore deposits and the increased complexities of mechanical and re-active beneficiation has progressively distorted the balance of the mining industry, in that in many countries the high cost of conventional mining has necessitated subsidies, tariff protection or other artificial means to keep the industries in being and permit the exploitation of the country's natural wealth. Sulphuric acid for leaching has been in use in copper mining for nearly a century. In more recent years it has also found application in electroylitic refining, and the latest development makes use of it in chemical beneficiation process of lateritic nickel ores. Already in the case of a few other metals or ores useful research results have been achieved, e.g. low-grade manganese ores. On the basis of ready availability of cheap sulphur supplies, there is scope for a broader large scale employment of sulphuric acid in this field of metal extraction especially if its uses were to reduce the present high cost of production of the rarer metals.

Fuel

In recent years the use of the exothermic combustion heat of sulphur has assumed increasing importance in sulphuric acid manufacture. Raw materials costs and in particular higher fuel costs have focussed plant makers' attention to this property and the recovery of steam plays today an essential part in the economics of sulphuric acid manufacure. Not only brimstone burners or pyrites flash and fluidised bed roasters are equipped with means to produce high pressure steam but now hearth roasters, probably the most popular roasting medium in the pyrites acid industry, are receiving this adjunct which is removing a major economic disability. The differences in the approach to the use of the by-product steam are of interest; in the U.S.A. generally, it is not charged but provides the means of executing a by-product operation which otherwise would have been uneconomical; in the United Kingdom and Western Europe, by-product steam used as such in secondary manufacturing processes—textiles, pigments, fertilizers, etc.—or for electricity generation, is charged competitively to reduce the cost of sulphuric acid. Thus sulphuric acid surplus to requirements acquires a cost-tag almost identical with by-product "fatal" acid. These relatively modest achievements open the way for research into the more extensive use of the fuel value of sulphur which under controlled conditions might open a major outlet for the industry.

Summary

Statistically, consumption of sulphur in 1965 has been forecast at 25 million tons in the Free World augmented by nearly 5 million tons in the U.S.S.R., China and other Communist Countries. Imposing up-to-date details of world sulphur consumption on the growth picture, produces a trend indicating a lower level of use of about 21 million tons sulphur in 1965. Whichever level is attained the long-term demand in the light of growing food, fuel and chemical energy requirements point to the re-establishment of a relatively narrow balance between supply and demand although recovery —both as a primary product and as part of the secondary process sequence—would inevitably broaden the base of the supply picture.

The anxieties about the rate of expansion of sulphur use, stem from excessive surplus of production capacity over anticipated uses in the early sixties and the consequent danger of a price collapse. This might accord with orthodox economic tenets but in terms of the life and scope of the industry it cannot be accepted as it would result in major dislocation and would destroy the confidence of the majority of users who require stability more than an exceptionally low sulphur price. As it is, sulphur has advanced least in price compared with other industrial raw material and even an increase from present levels would not deprive it of its chief favourable characteristic, that of low cost chemical energy. It cannot, however, be denied that the cheaper sulphur becomes, the greater the scope for research to find the new uses and outlets on which the future of the sulphur industry depends.

BRIMSTONE PRODUCTION IN WESTERN CANADA

RECOVERY OF BRIMSTONE from natural gas in Western Canada during 1958 totalled 178,300 tons, approximately one-fiifth of Canada's output of sulphur in all forms. Although it showed an increase of 75% over 1957 it employed only 48½% of installed capacity. Sales totalled 91,500 tons, the bulk of which were delivered to Western Canada pulp mills and sulphuric acid makers, but exports of only 5,000 tons made, as yet, no impact on the adjacent United States market. Increased gas deliveries rising in 1959 to 600 mmcf per day will be processed from equal quantities of sweet and sour gas, some of which will be drawn from new fields; sulphur output will in consequence grow to an estimated annual level of about 300,000 tons. Okotoks, which began production on 31st May 1959, and Nevis, which is scheduled to come on stream in the autumn, are the only two new plants to enter operation this year. A number of other plants are planned for completion in 1959 but it is not expected that they will begin production until next year. Their completion will raise total installed capacity of Canada's sulphur recovery industry to 1.2 million tons.

The following table shows an estimate of the sulphur output of individual operators for 1959.

ESTIMATES OF SULPHUR PRODUCTION—1959

Company	*Location*	*000 tons Capacity*	*000 tons Production*
British American Oil Company	Pincher Creek	148.5	145.0
Imperial Oil Company	Redwater	3.3	3.5
Royalite Oil Company	Turner Valley	12.0	7.5
Shell Oil Company	Jumping Pound	33.0	31.0
Jefferson Lake Petrochemicals of Canada Ltd.	Peace River	168.3	75.0
Steelman Gas Company	Steelman	2.5	2.0
Texas Gulf Sulphur Company	Okotoks	122.0	27.5
British American Oil Co.	Nevis	24.7	5.5
	Total	**514.3**	**297.0**

Developments in 1959

Okotoks. On 31st May 1959 Texas Gulf Sulphur Company began operations at the new $8 million sulphur extraction plant at Okotoks 25 miles south of Calgary. The plant, which covers an area of 200 acres and employs between 40 and 50 men, is owned jointly by Texas Gulf Sulphur Company (42½%), Devon Palmer Oils Ltd. (42½%) and Shell Oil Company of Canada Ltd. (15%). Brown & Root Inc. constructed the unit which daily processes 30 million cubic feet of gas from which 12 million cubic feet of sweet dry gas and 370 tons of high purity sulphur are produced. The processed gas has been made available to the Canadian Western Natural Gas Co. Ltd. in Southern Alberta. The Okotoks sour gas field was discovered in May 1951 by Shell Oil Company of Canada Ltd. and at present produces gas from 10 wells. The operators, Devon Palmer Oils Ltd., a subsidiary of Rio Tinto Company of London, are drilling a further well which has reached below the 8,000ft. level.

Nevis (I). For a number of years the British American Oil Company Ltd. has produced residual gas, LPG's and natural gasoline at Nevis from solution gas piped from the Stettler and Fenn Big Valley oilfields. To meet the rising gas requirements, Trans-Canada Pipelines will, on the 1st November 1959, start taking gas from the Nevis field, where British American Oil Co. Ltd. is developing gas facilities capable of treating 30% of the arising crude gas. This has an H_2S content of 6.8% and the expansion plans provide for a recovery plant with a daily capacity of 75 tons brimstone.

Nevis (II). The remaining 70% of gas supplies from the Nevis field are to be processed at Alix by the group of producers at present operating in the area and known as the Nevis Committee. Their gas processing plant, which is to incorporate a sulphur

Aerial view of the sulphur recovery plant at Okotoks.

recovery unit with a daily capacity of 100 tons, will be operated by Standard Oil Company of California.

Pincher Creek. The third and final phase of British American Oil Company's 675 tons sulphur recovery plant at Pincher Creek is due for completion before the end of this year. Ralph M. Parsons of Los Angeles have been engaged to supply and erect the third 225-ton unit which is similar to the other two plants which this company has already constructed at Pincher Creek. It is estimated that British American Oil Co., who produced 77,926 tons sulphur in 1958, representing 52½% of installed capacity, will raise their output to nearly 150,000 tons by the end of the current year.

Peace River Field. Jefferson Lake Petrochemicals of Canada Ltd., who produced in 1958 55,900 tons sulphur representing 33% of capacity, placed the entire output in stockpile. The completion of the rail link and the concurrent construction by the company of rail loading facilities at this plant and of dock facilities in Vancouver provide the transport means on which to base their expanding sales programme. The company is reported to have contracted for 1959 sales to local industries of 60,000 tons and it is expected that the output will rise to 90,000 tons by the end of this year. The bulk will originate from the old plant but it is anticipated that at least 8,000 to 10,000 tons will originate from the new installations due on stream in November 1959, which are reported to have capacity of 100,000 tons. During the first quarter of this year Jefferson Lake shipped 11,000 tons.

Savannah Creek. Jefferson Lake Petrochemicals of Canada Ltd. plan to construct a 115,000 tons sulphur recovery plant. A contract was recently negotiated with West Coast Transmission Co. for the export of 0.8 mmcf of cleaned gas to the United States and this awaits final approval from the Canadian Government and the U.S. Federal Power Commission.

East of Calgary. The third and largest addition to Jefferson Lake's expanding sulphur interests in Canada is the 297,000-ton plant which is to be built east of Calgary. Gas from this area is to be exported to the United States when final approval is given to their proposed contract by the Canadian Government and the U.S. Federal Power Commission.

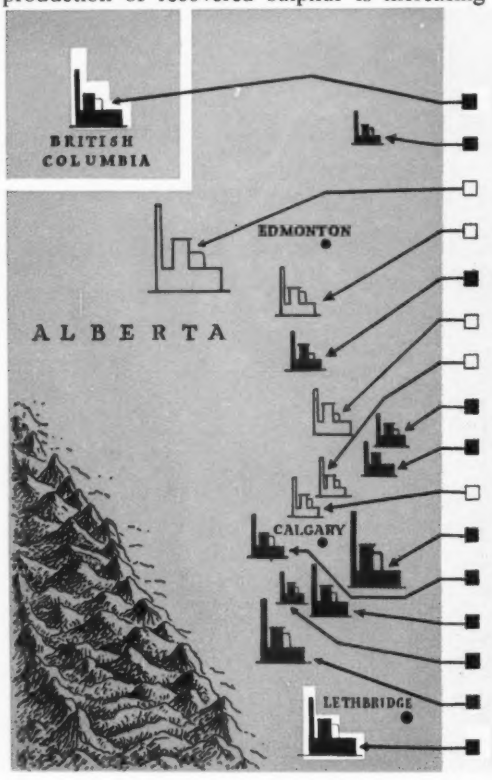
Future Projects

The aggregate sulphur recovery capacity of established plants and installations under

or scheduled for erection by 1960 totals 1.14 million tons per annum. In addition a number of projects await confirmation and in many cases specific plans do not appear to have been made. Should they materialise, the total level of capacity will be raised to 2.05 million tons per annum.

National Energy Board

The statistical picture shows how, as the result of the expansion of gas deliveries, production of recovered sulphur is increasing and, what is more, as expansion plans of gas producers—large or small—are being realised, additional gas cleaning and sulphur recovery capacity is being installed. The rigorous recommendations of the Borden Commission coupled with the continuing ban on new gas exports to the U.S.A. has imposed a brake on the rate of development and, apart from local Albertan demand, the industry is at present sustained only by the requirements of existing lines of the Trans-Canada Pipelines Ltd. to the East and West Coast Transmission Company's network through British Columbia to the North-Western United States. These two pipeline companies are not expected to exceed this year an aggregate daily rate of supply of 600 million cu. ft. of gas. This static situation is, however, about to be transformed by the establishment of a National Energy Board, in respect of which a Bill has been introduced in Parliament. The Board can be expected to guide the oil and gas industry through a new and dynamic phase in its developments, and the authorisation of gas exports on a large scale is expected to become one of its first decisions. The crucial duty which Parliament is imposing on the Board is the determination



Company	Location	Capacity 000 tons	Date on stream
Jefferson Lake Petrochemicals Co Ltd.	Peace River	168	11/57
	Peace River	100	1959
Imperial Oil Company	Redwater	3	12/56
Pan-American Sulphur, Hudson Bay Oil & Gas, Canadian Fina	Edson	660	Project
British American Oil or Standard Oil of California	Dick Lane	50	Project
Standard Oil Company	Home/Glen Rimbey	63	Project
Canadian Oil Company	Innisfail	66	Project
Mobil Oil Co., & British American Oil Co.	Wimbourne	33	Project
British American Oil Co.	Nevis	25	8/59
Nevis Committee	Nevis	40	9/59
Shell Oil Co., Hudson Bay Oil & Gas	Olds	33	Project
Jefferson Lake Petrochemicals Co. Ltd.	E. of Calgary	297	1959
Shell Oil Company	Jumping Pound	33	1956
Texas Gulf Sulphur Co. and Devon Palmer Oils	Okotoks	122	5/59
Royalite Oil Company	Turner Valley	12	1/57 and 7/58
Jefferson Lake Petrochemicals Co. Ltd.	Savannah Creek	116	1959
British American Oil Co.	Pincher Creek	149	1956
	Pincher Creek	74	1959

Fig. 2.

of the size and type of energy exports and the correlation of prices of different forms of energy, but it is significant that the transmission by pipeline of sulphur and other gas by-products is also being placed under the Board's jurisdiction. Probably the most controversial provision in the Bill is the Board's power to determine pipeline tolls which shall be " just and reasonable," and in the words of the Minister of Trade, the Hon. Gordon Churchill, " sufficient to attract capital for replacement and expansion," but against which there is to be no appeal.

Summary

Natural gas as a highly competitive form of fuel or chemical energy has its ready markets at prices offering a profitable return on the heavy investment in production plant and pipelines, and the expansion of gas sales at home and for export is not in doubt. As sour gas represents a very large proportion of reserves in Western Canada, the processing and disposal of the by-products obtained in purifying gas cannot be easily set aside, especially as some experts hold the view that before long the value of by-products may well exceed the value of the purified gas. Of the by-products in providing saleable clean gas, the problems besetting the disposal of sulphur are no nearer solution. Pressure on the railway companies to substitute a special tariff similar to that on grain for the present rates—which between Calgary and Vancouver amount to $9.58 per long ton, and which to Great Lakes destinations would exceed the cost of competitive sulphur—alternates with feasibility studies of a large capacity corrosion resisting pipeline to carry H_2S to the major consuming centres for conversion in situ. In view of the low level of world sulphur prices at the present stage of competition and ample supplies, producers face the alternative of either entering markets competitively for a very low return or to await higher prices as demand grows in time.

The major interest of Jefferson Lake Sulphur and Texas Gulf Sulphur Companies in the sulphur industry of Western Canada is without doubt a steadying influence, but the rapidly broadening base of production resulting from the growing number of sour gas operations points to mounting pressure of Canadian sulphur supplies on nearby markets with little regard to relative costs. It is expected that in 1961 production will reach the annual level of 1 million tons, but no pointer has yet emerged where and in what volumes sales would develop after the early part of 1960, when West Canadian and North-Western United States markets, which total about 300,000 tons, are satisfied.

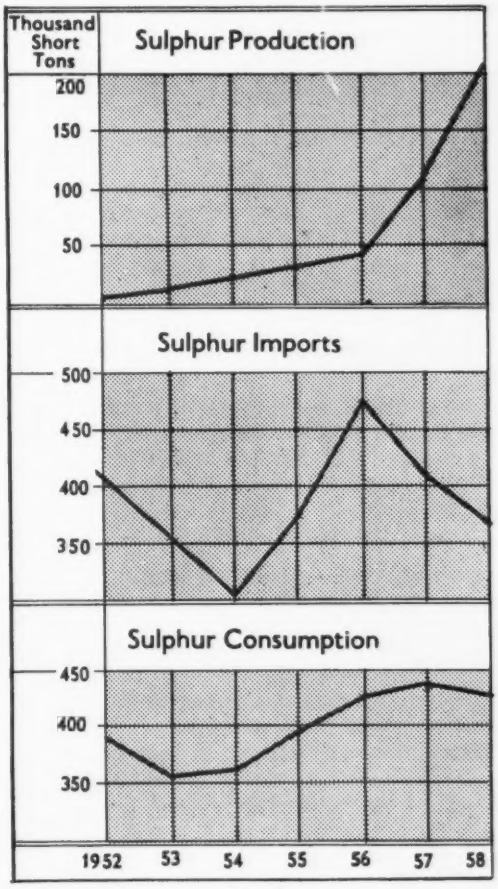


Fig. 3.

Prices and Trends

THE HOPES of a wide cross section of the World Sulphur Industry that a measure of price stability may be re-established, have been disappointed for the time being despite sincere endeavours in the late Spring on the part of several prominent producers and producer groups, towards achieving this desirable state. There has been a significant short-term improvement in the statistical position as the result of continued restraint of output of the U.S. Frasch sulphur industry which at a time of strong domestic demand caused stocks to decline to a level of about three-quarters of a million below that in the summer of 1958. There can be little doubt that the failure to hold the already low price level of the opening months of this year is attributable to the lack of mutual confidence amongst the major brimstone suppliers and the endeavour of each to attain or hold positions of short-term advantage in specific markets. Although there has been no new development to change the known medium term picture of growing oversupply in 1960-1963, the critical dates for the completion of several projects are coming uncomfortably near and hopes of major increases in demand are no longer able to divert market sentiment. This applies in the United States eastern market where individual purchases tend to be of exceptional magnitude and particularly in Europe where traditionally buyers seek to benefit from weak markets but accept as a corrollary the penalty of high prices when supplies are short.

These conditions which find expression in considerable market sensitivity tend to bring into focus the reactions of the major producers. Of immediate significance is the decision of the Pan American Sulphur Company to raise output 25% to an annual rate of one million tons and to broaden the base of sales correspondingly, and that of the United States Frasch sulphur producers whose sales position at home and abroad has stiffened in the face of competing interests.

The fortunes of the European pyrites industry have in recent months taken a turn for the better. The drastic reductions of the pyrites export prices provide a platform from which the industry can not only stem the serious drift to brimstone evident in most European acid industries, but make out a reasonable claim that, in specific locations, the use of pyrites is unquestionably more economic. The monetary and economic reforms in Spain have contributed, in no small measure, to the industry's determination and ability to rebut further inference of its progressive demise. Technical improvements, such as heat recovery from hearth roasters, and the constant appraisal of the best valorisation of the metallic constituents of pyrites are giving new strength to this sector of the sulphur industry, but this rests in no small measure on the solidarity of European pyrites producers and the support of Duisburger Kupferhütte to whose policy much of the success and undoubtedly the spirit of the pyrites revival, may be attributed.

In view of the decisive influence of ocean transport on the brimstone and pyrites sectors of the sulphur industry, as on other raw materials suppliers, a change in the state of the shipping industry would re-introduce a potent variable into marketing conditions. A return to "normal" freight market conditions appears to be still some two years distant, although the rate of scrapping of out-of-date and uneconomic tonnage is accelerating and the reduced number of new, albeit faster and bigger, vessels is beginning to make itself increasingly felt. The surfeit of shipping does not extend to all types of vessels and already there are occasional shortages of tonnages which are reflected in spot rates.

PRICES

Brimstone

United States Frasch sulphur prices for domestic and export markets remain posted at $25 per long ton f.o.b./f.a.s. U.S. Gulf Ports for bright material. Producers selling off-colour sulphur continue posting this grade at a discount of $1 per ton below the respective f.o.b. prices for bright and off-colour sulphur. In the industrial centres of the Eastern United States and amongst the fertilizer producers, notably in Florida, the practice of quoting delivered prices is now commonplace. Quotations range from $24 to $28 per ton and competition has

acquired a new edge following the reported intention of one of the principal U.S. producers to equal Mexican delivered prices. The notable feature of the market is the widespread improvement of customer service which producers render in preference to competing by way of price reduction. Efforts are centred on liquid sulphur supply, the benefits of which may aggregate under certain conditions more than $1 per ton. The world wide intensification of export sales promotion by The Sulphur Export Corporation meets many obstacles in view of Mexican and French sulphur sales, especially in North-West Europe, where delivered prices range from $25-28.50 per ton.

Mexican Frasch sulphur remains based on a price of $23.50 per ton f.o.b. Coatzacoalcas for fully filtered yellow material. Sales of unfiltered material are now at a low level and prices for off-colour supplies range down to $20.50 per ton f.o.b. The benefits of cheap ocean transport extend the range of competitive Mexican sulphur supplies into Canada and the Great Lakes area where it is reported to have been landed at $26-$27.

In Italy Ente Zolfi Italiani have, in recent months, slightly reduced their export prices which are now as follows:—

"Gialli Extra" Lire 19.000 per metric ton f.o.b.
"Gialli Comuni" Lire 18.000 per metric ton f.o.b.

Domestic prices for these qualities remain, however, at Lire 48,800 and Lire 47,000 per tonne f.o.r. respectively.

The selling price of French recovered sulphur of Société Nationale des Pétroles d'Aquitaine takes full account of any changes in the landed price of U.S. or Mexican sulphur in the respective markets. Benefiting from lower freight rates to European destinations, the average net return to this supplier is substantially above comparable returns in the U.S. or Mexico.

In Western European countries the domestic price of recovered sulphur has not changed appreciably but everywhere the weakening world prices have forced domestic suppliers to make some price adjustments. In West Germany the domestic price of brimstone recovered from spent oxide from Ruhrgas A.G., and from oil refinery gases is reported to be D.M. 110-120. In Belgium and Holland the price of domestic recovered sulphur is reported at B.Frs. 1,500 and D.Fl. 105 respectively. In Scandinavia the effect of intensive competition between imports from U.S., Mexico and France at a time when the pulp and paper industry has not fully recovered from last year's recession, has depressed landed prices to Sw. Kr. 155-160. Domestic supplies of brimstone recovered from oil shales by Svenska Skifferolje A.B., are quoted at Sw. Kr. 170-190. The price of brimstone recovered by Orkla Metal A.S. from smelting cupreous pyrites is now also lower, in keeping with world prices.

In Western Canada recovered sulphur prices range from $23-25 f.o.b. recovery plant. Export quotations are reported at $23.50 f.o.b. Vancouver, disregarding the transport cost element in order to remain competitive in world markets.

The following table indicates particulars of the delivered cost of brimstone of varying origin at principal consumers' destinations based on posted prices and ruling freight rates. The rates shown are either actual charters made at the end of July or reliable indications.

f.o.b. Country of origin	*U.K.*		*N.W. Europe*		*France (Mediterranean)*		*India*		*Australia*	
U.S.A. $24-25 ...	(43s.)	£10¾-11⅛	(35s.)	£10¾-10¾	(45s.)	£10⅞-11¼	(60s.)	£11⅛-12	(55s.)	£11⅛-11⅜
Mexico $20.50-24	(43s.)	£9½-10¾	(35s.)	£9-10⅜	(45s.)	£9½-10⅞	(60s.)	£10¼-11⅛	(55s.)	£10-11⅛
Italy Lire 18,000	(30s.)	£11⅞	(25s.)	£11⅛	(22s.)	£11½	(50s.)	£12⅛	—	—
Canada $23.50 ...	(60s.)	£11⅛	(55s.)	£11⅛	(55s.)	£11⅛	(70s.)	£11⅞	(60s.)	£11⅛

Pyrites

Pyrites prices in European markets have remained unchanged. Rio Tinto and Tharsis crude fines pyrites are quoted at 67s. 6d. per tonne f.o.b. Huelva basis 48%S and Portuguese export pyrites at 65s. per tonne f.o.b. Setubal and Pomaron. Norwegian and Cypriot pyrites are quoted competitively. The export value of Cypriot iron pyrites in the first six months of this year was 61s. 6d. per ton. Residues values are also unchanged although the improved offtake of iron ore and purple ore in W. Germany should, if continued, provide favourable grounds for an upward revision.

The outstanding event bearing on the

European pyrites price structure is the devaluation of the Spanish Peseta which occured on 18th July, 1958. The new rate of Pesetas 166.80/£1 augments the Pesetas revenue of Spanish pyrites producers by over 40%, but it would be rash to assume this to be their new competitive margin since, apart from the higher cost of imported stores and plant, the devaluation is accompanied by measures reshaping the Spanish economy which would ultimately tend to balance this short term advantage. Nevertheless for the first time for many years Spanish pyrites have the ability to dictate a price level, should they so wish instead of being obliged to follow the trend.

The export price of Yugoslavian pyrites has been aligned with that of other European producers and thanks to low cost transport by Danube barge to Central Europe they are claiming a growing share of the market.

The domestic price of pyrites in Portugal has been increased but it remains below the level of export prices; in Spain the domestic pyrites price is now in terms of pesetas, after devaluation about one third below the export price equivalent.

SUPPLY

In the United States the expansion of industrial activity in the Spring—reflected in the sulphur industry, primarily by intensive fertilizer manufacture and the pre-strike boost of the steel industry—raised sulphur demand to an annual rate of over 6½ million tons. Production of Frasch sulphur continued to be held below 390,000 tons per month, but imports from Mexico advanced to over 60,000 tons per month and recovered brimstone supplies rose to a similar level. At the same time other forms of sulphur supply participated in meeting the greater demand, notably alkylation sludge acid which now arises at an annual rate of 235,000 tons sulphur equivalent. The three-quarter million tons decline in producers' brimstone stocks and the reduction of about one-quarter million tons in consumers stocks was achieved whilst production capacity—now only about 60% employed—is due to rise within two years by some 1½ million tons as the new Lake Pelto and Grand Isle domes and possibly also High Island dome come on stream.

In Mexico Frasch sulphur production is now at an annual rate of 1½ million tons as Pan-American Sulphur Company advanced operations 25% to one million tons per annum and Texas International Sulphur Company entered production with the new Texistipec dome. The greater U.S. import demand was reflected by the growth of the proportion of Mexican exports—now 62% of about 100,000 tons — destined for the U.S. market. Stocks of Mexican Frasch sulphur total about three-quarter million tons.

In Italy fused sulphur production is now reduced to an annual level of 120,000 tons, but there is a mounting output of sulphur concentrates and increasing quantities of sulphur ore for acid manufacture. Refined sulphur output in Japan remains, in the absence of a significant advance in demand from either the rayon or the pulp industry, restricted to about 200,000 tons per annum. Sulphur production in China is reported to be expanding as operations in the Chilien Mountains gather pace. Exports are at present restricted to the U.S.S.R. and to North Korea. In the Western Ukraine and East Poland exploitation of sulphur ore deposits is reported to be advancing more rapidly as development difficulties are being resolved.

Recovery

In the U.S.A. the average level of monthly deliveries of recovered sulphur has risen to 53,000 tons. Construction activity continues adding to the installed sulphur recovery capacity, notably at oil refineries. The development work by the Tidewater Oil Company, at the New Hope, Texas, high sulphur bearing sour gas field, will shortly result in the addition of 224 tons recovery capacity daily. The recovered sulphur industry in W. Canada has remained static in recent months but rising natural gas deliveries to the East and through British Columbia to the U.S.A. and the imminent completion of new gas cleaning and sulphur recovery capacity, coupled with the early authorisation to export gas to the U.S.A., is about to take the industry another step forward. With a view to future exports substantial sulphur loading facilities are being planned and installed at Vancouver.

At Lacq sulphur recovery by Société Nationale de Pétroles d'Aquitaine has risen to a monthly rate of 40,000 tons, an advance of 10% during the past six months. During the second quarter production totalled 97,200 tons of which 41,900 tons was delivered to French users and 39,700 tons were exported.

The oil refinery expansion programme in Europe entails major additions to sulphur recovery capacity. These are expected at the Caltex project in Holland, the Esso refinery at Karlsruhe and most significantly at the E.N.I. refinery at Gela in Sicily which may produce as much as 240,000 tons per annum.

Pyrites

Shipments of European pyrites after declining slightly in the early months of the year advanced under the stimulus of slow but steady improvement in acid demand. The general level of deliveries, mainly due to the adverse export picture of Spanish pyrites, is still about 10% below that of 1957. Exports from Cyprus continue, totalling 528,000 tons during the first six months, including 159,000 tons cupreous and 379,000 iron pyrites, the latter having increased 10% during the second quarter. Portugal consumes domestically an increasing proportion of its annual output of 600,000 tons pyrites. Of the three pyrites mines the useful life of Mason & Barry's San Domingos mine is now estimated at only seven years at the present rate of output of 130,000 tons for sale and smelter. The policy of the two major producers, Mines d'Aljustrel and Mines et Industries, which meets the Government view point, is to avoid an excessive rate of exploitation. Exports of cupreous pyrites from Cuba, mainly to Italy, are being maintained.

Whilst the scaling down of the Sulphur Bounty in Australia will put a brake on the expansion of pyrite use, Mount Morgan Ltd., with the financial support of the Queensland Government and possiby co-operation of a fertilizer producer, aims to convert the large stocks of pyrites tailings at the mine into sulphuric acid for fertilizer — ammonium sulphate or phosphate—manufacture. In Cuba, Venezuela, Taiwan and Southern Rhodesia expansion of indigenous pyrites supplies and use is taking place and is also reported from China and East European Communist countries where the shortage of sulphurous raw materials and sulphuric acid imposes a brake on expansion of fertilizer output.

FREIGHT

The voyage index of the United Kingdom Chamber of Shipping further declined from 65.1 in March to 64.6 in May, but under the impact of some coal demand advanced to 69.2 in June. In a generally weak freight market the continuity of ore and fertilizer shipments has provided a small measure of stability. Nevertheless the further general decline of freight rates also manifested itself in a weakening of many sulphur and pyrites charters. Rates for larger vessels, 9,000 tons and more, on transatlantic and distant voyages appear to have receded, but the relative shortage of medium-sized vessels and on occasions spot requirements of small-sized tonnage has entailed a few fixtures above current market rates. From the Gulf of Mexico to the United Kingdom recent fixtures were at 42s. 9d. f.o.b. at current rates of discharge; to the Continent rates ranged from $4.20 to $5.00, although in June a 9,000 ton vessel to Rouen was fixed at $5.70 f.i.o. From Bayonne to the United Kingdom charges are based on 19s. f.i.o. but to the range of N.W. European ports the accepted rate appears to be 15s. f.i.o.

Distant charters remain unstable. From the Gulf to New Zealand a recent fixture was made at 69s. 6d. providing for two-port discharge 50c. loading and current rates discharge. To India, East and West Coasts, quotations correspond to about 60s. f.i.o. To Brazil the rate from U.S. Gulf ports ranges from $4.75 to $5.25. Pyrites charters from Huelva to Antwerp in medium-sized vessels are being concluded at 23s. (2s. 6d. loading, 2s. discharge) and 27s. 6d. to U.K. ports. Whereas previously for large vessels to Rotterdam and Hamburg a rate of 20s. 6d. was being charged by Italian vessels attracted to this trade, this is now wholly in the hands of the German Chartering Group based on long term charters, reported to be at an equivalent of 26s.-27s. From Cyprus to N.W. Europe rates have recently been subject to slight fluctuation and 9,000 ton vessels fixed at 25s. and at 27s.

UNITED STATES SULPHUR

THE SPECTACULAR RECOVERY of the U.S. economy which carried the index of industrial production from the low point of 126 in March 1958 to 158 in June of this year (1947/9 = 100) was accompanied by a significant growth of sulphur consumption. Booming steel industry, strong activity in oil refining, textiles (notably tyre yarns), pigments and chemicals in general, but above all an outstanding expansion in fertilizer manufacture to meet exceptional demand, all contributed to raise sulphuric acid manufacture to an annual level of 18 million short tons. In response to demand from acid and non-acid users, Frasch sulphur deliveries advanced strongly, resulting in important reductions of producers' stocks, as there was no significant increase in the low production schedules established late in 1958. Sulphur imports from Mexico increased sharply in the late spring, as did also deliveries of recovered brimstone, pyrites and various by-products, notably oil refinery sludge.

Frasch Sulphur

Production of Frasch sulphur in the first quarter of 1959 of 1,037,770 tons, was the lowest in any quarter since U.S. producers decided to align production more closely with sales in 1957. It represents a decrease of 25% compared with the corresponding period last year, and of about 10% compared with that in 1957, and expressed as an annual rate of Frasch production—4.1 million tons—it was at the lowest level since 1946.

Producers' policy to maintain output at a low level is coupled with a selective employment of production facilities. In general, producers find it more economical to operate the smaller properties at a high rate of capacity and to control the overall output by an adjustment of operations at their larger mines. This applies in particular to the Texas Gulf and Freeport Sulphur Companies. The reduction of stocks which has been the outcome of keeping production down at a time of rising sales should be reflected in financial results.

Texas Gulf Sulphur Co. further reduced activities at Boling dome where late in June, as part of rationalisation measures, a 10% staff cut was effected. The installations at the company's other domes—Spindletop, Moss Bluff and in particular Fannett—appear to be working nearer their designed production rates. Molten sulphur shipments moving through the company's distribution centre at Cincinnati, Ohio, and deliveries by way of the sulphur terminal at Tampa, Florida, are assuming importance in a market which is paying increasing attention to service. The Freeport Sulphur Company is not now expected to start operations at the new Lake Pelto dome this year. These are scheduled to start on conclusion of mining activities at Bay St. Elaine,

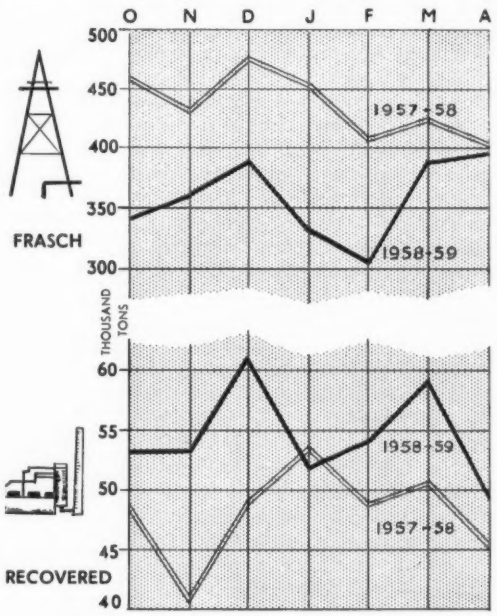


Fig. 5. Monthly production

when the barge-mounted power plant will be available to move to Lake Pelto and be sited on a 7-acre island approximately one mile north-west of the ore body. Lake Pelto dome is just beyond the coastal marsh area separated from the open water of the Gulf of Mexico by a thin strip of land which forms part of the Isles Dernières and it will be necessary to protect the plant against hurricane waves. Auxiliary facilities such as camps, shops and offices will also be located on the island, and

the sulphur output will be moved by barge to Port Sulphur. The Grand Isle project is progressing rapidly, but no change is envisaged in the anticipated start-up date of 1961.

Apparent sales of Frasch sulphur during the first quarter at 1,154,426 tons exceeded production and caused a withdrawal from stocks of nearly 120,000 tons. Compared with the corresponding quarter last year sales had advanced approximately 5%, mainly on account of the improvement in the domestic market estimated at 15% and affected by the lower volume of exports, which only totalled 278,026 tons. The upturn in sales was not unexpected as the U.S. economy had shown vigorous signs of expansion in the second half of 1958 and economists confidently foretold record productions would be achieved in most industrial sectors. The repeated withdrawals from stocks each month brought the stockpile at the end of March to 4,325,410 tons, a reduction of over half a million tons since the record level of stocks of 4,886,779 tons in July 1958.

Recovered Sulphur

Recovered sulphur production, which totalled 165,125 tons during the first quarter, just failed to reach the record level of 165,400 tons achieved during the previous quarter. Nonetheless production was well maintained and many refineries were reported to be working in excess of their rated capacity. A notable example was the Tidewater Oil Co., who operate the world's largest sulphur recovery plant based on refinery gases. The plant has a capacity to produce 342 tons high purity brimstone per day and because of the high level of oil refining operations, output has been as much as 360 tons daily.

One of the major projects is the plant of Consolidated Chemicals Industries Inc. — a subsidiary of Stauffer Chemical Co.—which is located at Baytown, Texas, adjacent to the large Humble Oil & Refining Co. refinery whence it obtains its hydrogen sulphide. The recovery unit, which has a capacity of 124 long tons per day, was installed as a result of a major expansion at Humble Oil's refinery which includes new large hydrofining units. Built by the Ralph M. Parsons Co., of Los Angeles, it supplements the existing plant at Baytown so that total capacity at this location is now 194 tons per day. Consolidated Chemicals also operate a small plant at Baton Rouge, Louisiana.

The Allied Chemical & Dye Corporation has in the past eighteen months, also entered the field of recovered sulphur production and a plant with a daily capacity of 100 tons brimstone is under construction by the Ralph M. Parsons Co. at Richmond, California. Hydrogen sulphide is reported to be purchased from a local oil refinery in the same way as at the company's Bayway N.J. sulphur recovery plant which has capacity to produce some 60 tons per day.

Hancock Chemical Co. at Wilmington, California has recently completed a duplicate sulphur recovery plant in order to meet the regulations of Los Angeles Smog Board. Although the company's recovery capacity is thereby raised to nearly 300 tons per day of high purity brimstone, in effect the new plant does not add to employed capacity. Satisfactory progress has also been reported by the Anlin Chemical Co. who are constructing a 150 tons per day recovery plant at Wood River, Ill.

The number of sulphur recovery plants installed and their intensity of operation continues to increase and together with new plants to be built within the next twelve months it is expected that recovered sulphur production in the United States will total about three-quarters of a million tons during 1960.

Apparent sales of recovered sulphur continue to be well maintained, and, although only 1% greater than the previous quarter, reached a record total of 165,145 tons. There has been no change in stocks and at the end of March they totalled 177,527 tons.

Consumption

Rising sulphur consumption which became apparent in the latter part of 1958, was maintained in the first quarter of 1959 when total brimstone deliveries reached 1.23 million tons compared with 1.21 million tons in the previous quarter and only 1.07 million tons in the corresponding period last year. From January to March 1959 Frasch sulphur supplied most of the increased demand as recovered sulphur supplies were kept in line with production and as there was no change in the level of imports from Mexico which, during the

first quarter totalled 130,484 tons. The bulk of the additional sulphur requirements were consumed in the manfacture of sulphuric acid although demand by the non-acid sulphur sector, notably textiles and rubber has shown impressive increases.

Sulphuric Acid

Production of sulphuric acid during the first quarter has been at record levels and totalled 4.45 million short tons compared with 3.93 million tons in the corresponding quarter last year. Monthly details of production are as follows:—

SULPHURIC ACID PRODUCTION

000 short tons 100% H_2SO_4

	Jan.	Feb.	March
1959			
Gross total	1,464	1,406	1,580
Chamber	189	181	193
Contact*	1,275	1,225	1,386
Spent Acid	51	49	58
1958			
Gross total	1,351	1,214	1,364
Chamber	171	152	162
Contact*	1,181	1,062	1,201
Spent Acid	57	40	52

*includes Oleum and Spent Acid fortified

Stimulated by the upturn in general business activity and the threat of the steel strike which prompted steel makers to operate up to 94% of capacity, pressure on acid supplies progressively raised the level of production. Many Eastern States steelworks experienced difficulties in obtaining prompt supplies of acid and the market for sulphuric acid has been firm; amongst lesser consumers the aluminium sulphate industry was outstanding.

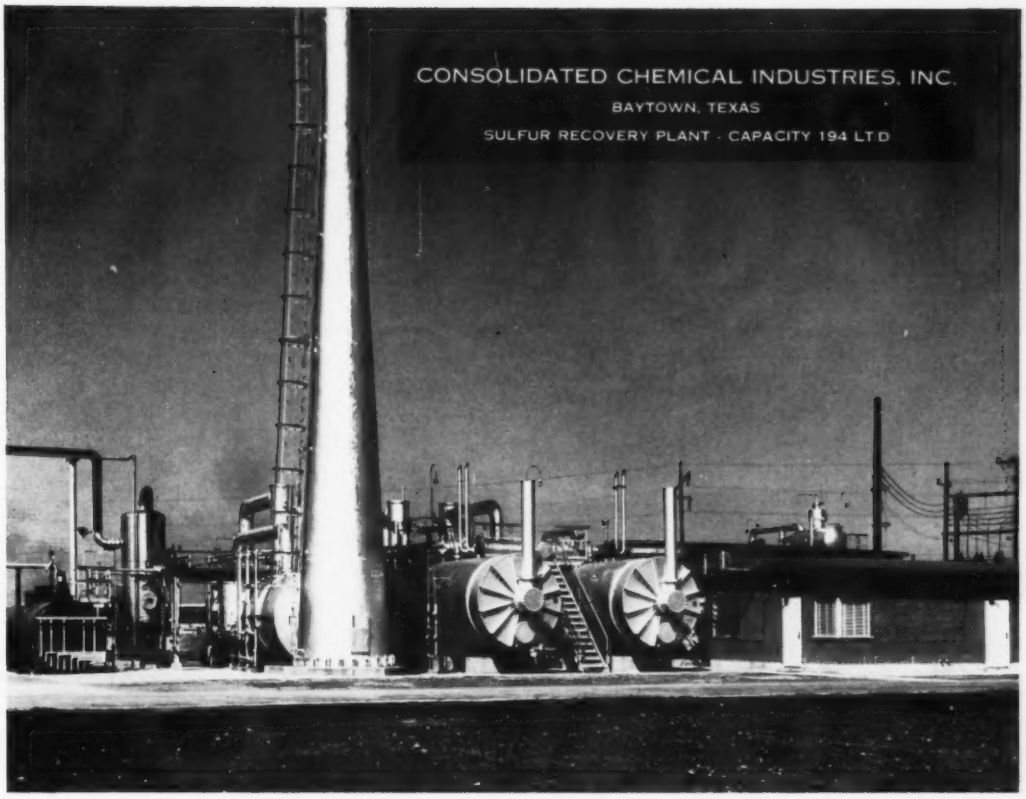
During 1958 there were many important additions to the sulphuric acid industry's capacity in all sectors. One of the largest plants completed was the 450 tons per day installation based on liquid sulphur for the Kermac Nuclear Fuels Corporation at Grants, New Mexico. Built by the Leonard Construction Co., of Chicago, it is of Leonard-Monsanto design and the acid is destined for captive consumption in the company's uranium oxide concentration mill. Leonard Construction Co. have completed a 150 tons per day plant for Fremont Minerals Inc., now renamed Susquehanna Western Inc. at Riverton, Wyoming—also for uranium leaching—a sceond plant for the Shamrock Oil & Gas Co. at Sunray, Texas, and a new by-product acid plant for the New Jersey Zinc Co. at the Palmerton, Pa. smelter. Modernising the sulphuric acid installations at Ecorse (Detroit), Michigan, of E.I. du Pont de Nemours Inc. adds modern contact plant with capacity of 300 tons per day and capable of operating on brimstone as well as sludge acid. The original Ecorse installation consisted of an old 100 tons per day chamber plant which was demolished.

Important acid expansions have also been completed in conjunction with the manufacture of titanium dioxide pigments. During 1958 American Cyanamid commissioned their Savannah plant (72,000 t.p.a. TiO_2 capacity) and integrated with this plant was a 250 tons per day brimstone burning unit built by Chemical Consruction Corp. of New York. At St. Louis, Mo., the Naional Lead Co. have completed a further expansion which includes a Chemico plant with a daily capacity of 350 tons.

The two most important projects under construction during 1959 will be based on the use of spent and sludge acids. The plant for Stauffer Chemicals at Hammond, Indiana, has a capacity of 600 tons per day and that for Dixon Chemical Industries at Paulsboro, N.J., 860 tons per day. Both these plants are being built by the Chemical Construction Corporation who are also building a 150 tons per day acid plant at Fresno, California, for Valley Nitrogen Producers in their nitrogenous fertilizer venture. A major fertilizer plant is also under construction by the J. R. Simplot Co. at Pocatello, Idaho, who, following their decision to become a producer of phosphatic fertilizers, are installing a Leonard-Monsanto plant based on brimstone with a capacity of 350 tons per day (100% H_2SO_4) and it is expected that it will be completed this year. Construction work is progressing satisfactorily at South St. Paul, Minn., for North Star Chemicals Inc. whose 200 tons per day plant is being built to meet the acid needs of the adjacent oil refinery as well as a large number of local industrial users.

Trade

Imports of sulphur from Mexico during the first three months totalled 130,484 tons, some 2% more than in the corresponding period last year. It is of interest to note that the average Mexican import price has shown a



decline from $23.00 in the first quarter 1958 to an average of $21.98 in the first quarter 1959. In addition to imports from Mexico there were imports from Canada totalling some 2,000 tons, compared with 500 tons in the first quarter of 1958.

Frasch sulphur exports totalled 278,026 tons, the lowest level of shipments during any quarter for several years, and 40,000 tons lower than in the first quarter of last year. Sales to Canada declined, but as imports are customarily low during this period this result is not conclusive. In the European market which was noticeably weak, American supplies are coming under considerable pressure from the Mexican Frasch and French recovered sulphur producers. Exports to Belguim have shown the largest reduction (14,000 tons) and totalled 9,400 tons only. Exports to the U.K. were 44,265 tons (−10,000 tons), to Austria 2,000 tons (−8,000 tons), and France 30,220 tons, (−7,500 tons). America's traditional export markets in the Eastern hemisphere also came under severe pressure and shipments to Australia declined 14,000 tons to 27,675 tons, and to India 10,000 tons to 21,310 tons.

United States exporters have paid particular attention to the growing Central and South American markets and, in recording higher sales in this area with the exception of Uruguay, have so far succeeded in retaining their monopoly. The principal market is Brazil and exports increased 21,000 tons to 42,554 tons. Exports to Cuba totalled 3,310 tons, compared with none in the corresponding period last year, but the real importance of this market will appear when the nickel project of the Freeport Nickel Company, incorporating the world's largest acid plant with a capacity of 1,350 tons per day, is completed.

SULPHUR IN MEXICO

AFTER A PERIOD of stable production during the past year accompanied by rising sales, Mexico's sulphur industry is once more poised for an advance. To meet the first half-year's commitments a considerable quantity of sulphur has been withdrawn from stocks; during this period Mexico's total export shipments have risen to nearly 560,000 tons, representing an advance of 19% over

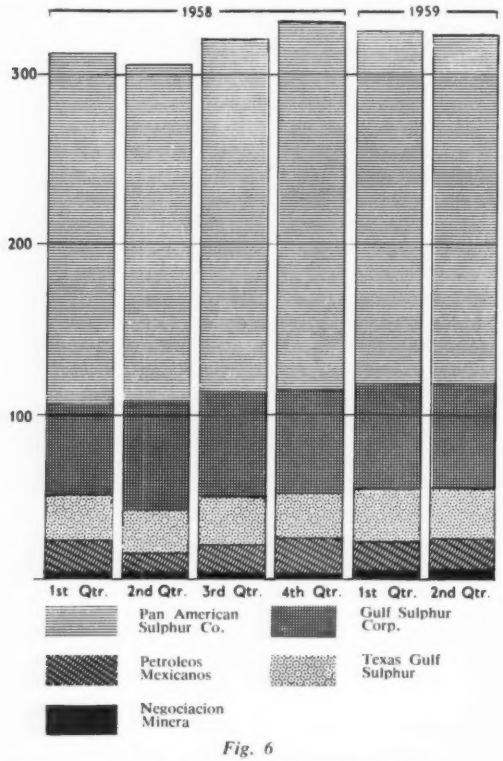


Fig. 6

the same period in 1958. The prime mover is again Pan American Sulphur Co., the world's third largest brimstone producer whose sales at home and abroad have expanded. The company's actual output during the second quarter has not shown an appreciable increase although in the latter part of June operations at Jaltipan dome were conducted at an annual level of 1 million tons. The regular higher rate of production achieved by Gulf Sulphur Corporation, coupled with the increased recovery activities of the state-owned Pemex and reported advent of Texas International Sulphur Company's Texistepec sulphur dome, points to Mexican sulphur output reaching a level of at least 1.4 million tons in 1959. A striking feature of the growth of the industry is the rapid increase in domestic sulphur demand, which at a monthly level of 10,000 tons now makes significant calls on Frasch sulphur supplies in addition to consuming all that Pemex and the native sulphur ore mines can produce.

Production and Stocks

During the period January-June 1959 total production from all sources is estimated at 659,000 tons, an increase of 7.7% compared with the first six months of 1958.

PRODUCTION

	1958	*1959*	*Change*
	000 tons		*%*
Frasch			
January-March	290	312	
April-June	298	309	
January-June	588	621	+ 5½
Recovered			
January-March	6	14	
April-June	9	15	
January-June	15	29	+ 93
Native			
January-March	4	4	
April-June	5	5	
January-June	9	9	—
Total			
January-March	300	330	
April-June	312	329	
January-June	612	659	+ 7.7

As a result of the higher rate of export deliveries the level of Frasch sulphur stocks declined in the second quarter by approximately 29,000 tons, but due to substantial additions made in the first quarter, stocks on 30th June were 43,000 tons greater than at the beginning of the year. Pan American Sulphur Company reduced their stocks by 66,200 tons, those of Gulf Sulphur Corporation increased by 48,600 tons and Texas Gulf Sulphur Company, con-

tinuing their policy of stockpiling the entire output, have added a further 60,500 tons.

Exports

As the result of shipping difficulties encountered in March, exports of about 234,000 tons for the first quarter did not fulfil earlier expectations. Since the beginning of April, however, shipments have expanded mainly as a result of Pan American's increased sales and in the second quarter shipments of 326,000 tons showed an advance of 39% over those of the preceding period. During the first half of 1959 exports to the United States rose considerably and were the main reason for the overall growth. This market has increased by 10% since the end of 1957 and to-day covers 62% of Mexico's total overseas sales. It is estimated that if the present level of operations is maintained, Mexico's exports in 1959 will exceed 1.2 million tons or 15% more than in 1958.

New markets include Peru (900 tons) and India (4,000 tons) whilst, contrary to the first quarter of 1959, no exports were made to Germany, Formosa, Canada and Sweden. The sulphur recovery operations at Lacq have had a severe effect upon exports of Mexican sulphur to France, with the result that during the first quarter of 1958 no sales were made to this market as compared with the 17,000 tons in the corresponding period last year. Exports to France improved slightly in April and May, but it is unlikely that Mexican shippers will be able to maintain their markets in that country.

PAN AMERICAN SULPHUR COMPANY

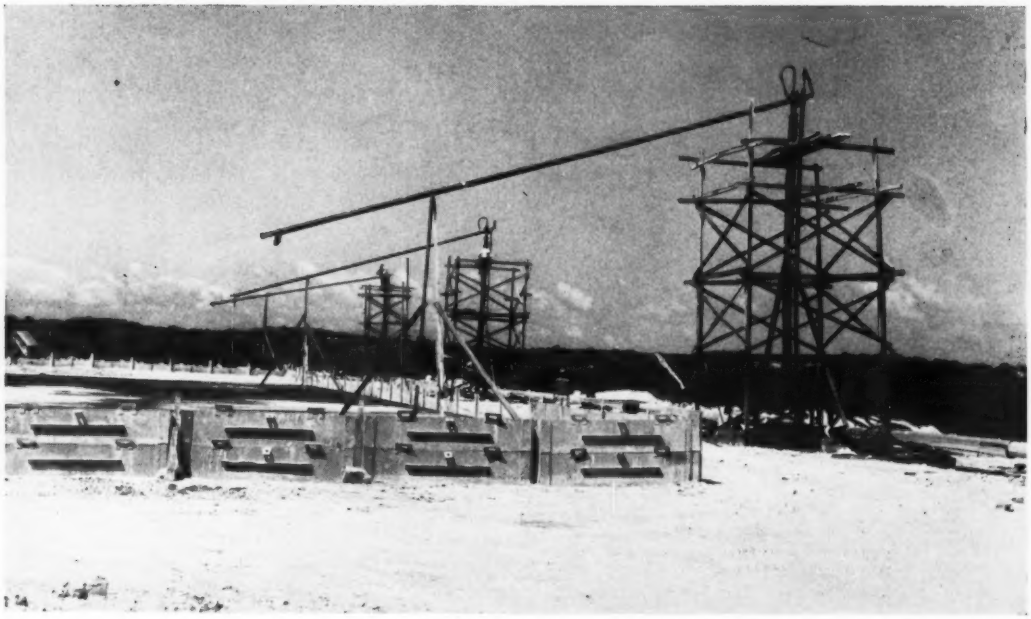
On June 28th 1959 the Pan American Sulphur Company produced the three millionth ton of sulphur from their Jaltipan dome in Mexico. The production of 205,494 tons in the second quarter of this year raises Pan America's total output for the first six months to approximately 412,000 tons compared with 409,000 tons in the first half of 1958. This in no way reflects the company's expanded activities, for it represents only a fractional increase compared with the same period in 1958.

To meet increased overseas commitments and also because of expanding supplies to domestic consumers, Pan American Sulphur Co. have reduced their stocks by 66,000 tons since the beginning of the year. Despite these severe reductions, the company's stockpile at the end of June contained approximately 487,000 tons, representing 6-7 months supply at the high rate prevailing in June. Exports during the second quarter rose to approximately 275,000 tons bringing the half-year's overseas sales to 462,000 tons, which shows an increase of 13% compared with the corresponding period in 1958. These results were achieved despite a severe cut in exports to France (−72%) and in part they reflect sales to new markets in Peru, Belgium and India. The liquid sulphur terminal at Tampa, Florida, is to begin operation at the end of July; this installation in addition to new dry bulk storage facilities due for completion in early 1960 will improve the company's service to customers. Sales to domestic consumers have increased more than eight-fold to nearly 17,000 tons and in view of Mexico's expanding economy it is likely that this market will provide the company with a growing outlet.

Pan American's earnings for the first half of 1959 were approximately $2.1 million or 91 cents per share as compared with the 68 cents per share obtained during the same period 1958. These increased earnings reflect the company's expansion and ability to compete with the established United States producers.

GULF SULPHUR CORPORATION

In the first half of this year the company produced approximately 149,000 tons which represents an increase of 23% compared with the same period last year. This accords with plans to raise the production level to 300,000 tons by the end of 1959. As the result of intense international competition, overseas sales have declined and for the first six months amounted to 104,500 tons, representing a 11% decrease compared with the last half of 1958. The company has, however, added nearly 50,000 tons of their output to stocks at Coatzacoalcos which are estimated to have risen to 110,000 tons representing about six months' shipments. This action remedies a disability which has been causing the company much anxiety in recent years. The company has recently entered into a sales agreement with Continental Ore Corporation of New York in



Gulf Sulphur Corporation. New vat under construction. Note vat loading towers are a sufficient distance from vat to offer complete clearance in breaking-out operations.

an endeavour to secure a larger share of the world's sulphur markets through the intermediary of the Corporation's world-wide trading links. The sales target for 1959 is 250,000 tons. Despite the lower sales revenue of $2.3 million, the management succeeded by a substantial ($½ million) cut in costs to reduce the net loss to only $70,000.

TEXAS INTERNATIONAL SULPHUR COMPANY

Heating of the Texistepic dome has now been completed and it is reported that the Texas International Sulphur Company produced 700 tons during testing. The technicians at the plant have succeeded in solving water circulation problems and Mr. Eugene Stack, the newly-elected President, announced recently that the plant has now begun regular production at a monthly rate of 9,000 tons. Its reported capacity is 100,000 tons per annum, but as yet no indication has been given of the company's marketing plans.

Recovered and Native Sulphur

Pemex have recently brought on stream a 25 tons per day sulphur recovery plant based on sour natural gas at Mexico City and are in the process of building a further 20 tons per day recovery plant at their Tampico refinery. Current output is at a monthly rate of 5,000 tons recovered brimstone. Native refined sulphur continues to be produced at a monthly rate of 1,400 tons.

Domestic Consumption

Although in 1958 Mexico's fertilizer industry initiated several major projects, production was relatively static; this year output is increasing. Expansion is much needed for there is still a gap of approximately 150,000 tons between consumption and production which causes a heavy drain on Mexico's financial resources. Pemex, Mexico's nationalised oil company, have announced that they plan to build three fertilizer plants in conjunction with United States funds, whilst Guanos y Fertilizantes are erecting a triple superphosphate plant at Coatzacoalcos which is due to be completed in 1960.

As a result of this increased activity and greater industrial demand, domestic consumption of sulphur is likely to rise still further

during the next five years. Already in the first six months of 1959 this market has consumed over 58,000 tons as compared with only 41,000 tons in the corresponding period in 1958. The bulk is used by Guanos y Fertilizantes, the State-owned fertilizer organisation, who have just brought on stream a further 150 tons per day sulphuric acid plant at their fertilizer installation at Cuautitlan.

Conclusion

The recovery in the U.S. from the 1958 industrial recession has been the main factor in the recent expansion of the Mexican sulphur industry. There is every indication that the industry is determined to maintain its position in its principal markets, notably U.S.A. and Europe, and to withstand competition from the new supplies of sulphur from Canada and France.

In the expanding economy of Mexico the sulphur industry is steadily strengthening its position and contributing increasingly to foreign exchange earnings. Sulphur income in the first four months of 1959 has risen over 20% compared with the same period of 1958, and despite low world sulphur prices is now at an annual rate of U.S. $24 million.

SULPHUR IN THE UNITED KINGDOM

THE STRONG advance in industrial activity which became apparent in the closing months of 1958 accelerated this year, and during the first six months the U.K. economy improved in virtually all sectors. The index of industrial production, seasonally adjusted, moved up from 108 to 110 between January and May, and compares with an average of 106 for the first half of 1958 (1954=100). Consumption of sulphur advanced to peak levels, and during the first six months totalled 474,000 tons*, 4¼% more than during the corresponding period in 1958. The increase was occasioned mainly by the greater requirements of the sulphuric acid industry and non-acid uses showed an advance of approximately 6% over the same period last year. Additional requirements were met in about equal parts from indigenous resources and sulphur imports. Of these pyrites shipments, conforming to the lesser demand, needed whereas imported brimstone supplies significantly increased.

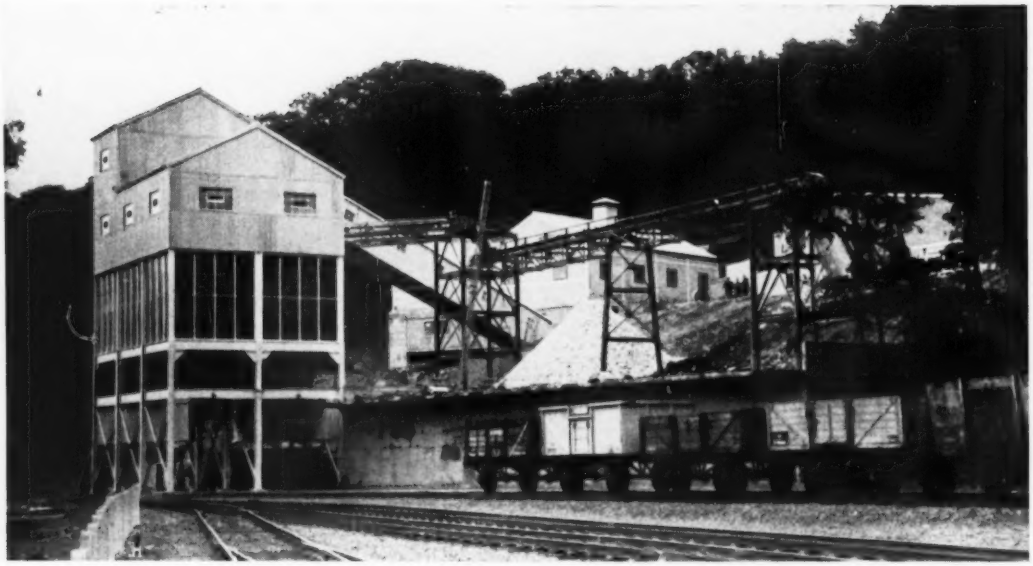
Consumption

With the increased level of activity throughout the U.K. sulphur industry the pattern of consumption of raw materials in the first half of 1959 became, as anticipated, more clearly defined. Brimstone use expanded, partly on account of the slight increase in non-acid sulphur use, but principally because the bulk of additional acid needs was met from brimstone acid plants; concurrently anhydrite consumption, at an annual rate of 770,000 tons, for sulphuric acid manufacture showed a slight advance to near peak levels. In contrast pyrites use at an annual rate of 320,000 tons is about 10% lower than in the first half of 1958 and consumption of spent oxide is now 15% lower. Greater use of recovered sulphur and H_2S and greater by-product acid manufacture, as the result of the improved zinc demand and consequent advance of smelter activity, resulted in indigenous sulphur supplies providing the equivalent of 192,500 tons sulphur compared with 183,500 tons in the first half of 1958.

CONSUMPTION OF SULPHUROUS RAW MATERIALS

	1st Half 1959	*2nd Half 1958*	*% Change*	*1st Half 1958*	*% Change*
Elemental Sulphur					
Total Acid	185,400	162,300	+ 14¼	160,100	+ 15¾
Imported	159,400	137,800	+ 15¼	139,800	+ 14
Recovered H_2S & filter cake	26,000	24,500	+ 6	20,300	+ 28
Non Acid	50,100	43,800	+ 14¼	47,200	+ 6
Total Elemental Sulphur	235,500	206,100	+ 14¼	207,300	+ 13½
Pyrites	159,500	149,800	+ 6½	177,900	− 10½
Spent Oxide	111,200	111,500	− ¼	131,200	− 15¼
Anhydrite	384,400	379,300	+ 1¼	369,700	+ 4
Zinc Concentrates	94,900	78,900	+ 20¼	73,300	+ 29½

* Excluding sulphur in anhydrite consumed in the direct manufacture of ammonium sulphate



Long Meg Mine, Cumberland. General view of the anhydrite crushing, screening and loading facilities.

SUPPLIES

Anhydrite. Two notable milestones were passed during the period under review by the anhydrite industry. In addition to its annual contribution of about 200,000 tons sulphur for the manufacture of ammonium sulphate by direct reaction with ammonia and CO_2, this is now the second largest source of sulphur supply to the sulphuric acid industry providing annually some 178,000 tons sulphur in the form of high grade anhydrite of about 20-21% S.

At the Billingham mine of Imperial Chemical Industries the 20 millionth ton of anhydrite was produced early this year. This mine has been extensively modernised and mechanised and current output is believed to be at an annual rate of $1\frac{1}{4}$ million tons. At the Long Meg Mine near Penrith, which was specially developed to supply the needs of the United Sulphuric Acid Corporation at Widnes, the millionth ton was produced in June. Mining activity being geared closely to that of the acid plant, the rate of production has in recent months been close to the mine's capacity, which is estimated at about 300,000 tons high grade anhydrite.

Spent Oxide. The severe drop in usage in recent months has accentuated the effect of the price of sulphur in spent oxide which fell sharply when world brimstone and pyrites prices declined. It is estimated the current level of supply of 220,000 tons annually brings in less than £$\frac{1}{2}$ million whereas only two to three years ago the tonnage used was 20% greater and the gas industry's revenue to offset purification costs was about £$1\frac{1}{4}$ million. To-day the gas industry experiences growing difficulties in disposing of even high grade oxide—in respect of which the revenue is less than 1/- per long ton unit of sulphur contained—and this reflects directly on the cost of gas, in that the financial burden of gas purification has become greater. Plans for the immediate future are reported to employ, increasingly, wet purification methods for the removal of the bulk of H_2S contamination to take advantage of the operating conditions which from practical and financial viewpoints are more favourable.

Recovered Sulphur. The inevitable fluctuations in the refinery programme of the oil industry have obscured the impact of the new sulphur recovery plant installations. The level of installed annual capacity is believed to be about 75,000 tons but current production is only about 55,000 tons per annum. As yet neither the output from the new plant at the

British Petroleum refinery at the Isle of Grain nor that of Esso Petroleum Company's new recovery unit at Fawley has made itself felt. The fire which recently damaged some of the installation at the Fawley oil refinery is also reported to have affected one of the two sulphur recovery plants; restoration of the recovery capacity of 28,000 tons high purity brimstone is, however, expected to be achieved speedily. At the Shellhaven refinery, plans for the construction of a new 20 tons per day sulphur recovery plant were reported recently. There is some doubt whether or not the large volume of H_2S, extracted from the refinery gas during purification prior to its sale to the North Thames Gas Board, is recovered or whether it is flared off.

The application of the Benfield wet gas purification process in conjunction with the various coal gasification projects will result in increasing quantities of H_2S being recovered which, once commercial scale plants enter operation, offers considerable scope for the manufacture of brimstone or by-product sulphuric acid.

Imports

During the first half of 1959 total imports —brimstone and pyrites—amounted to 214,500 tons sulphur compared to 199,200 tons in the same period 1958, an increase of 7¾%. Brimstone imports of 166,750 tons were 11½% higher than in the first six months of 1958 and accounted for 78% of total sulphur imports compared with 75% in the same period last year.

With the entry of French recovered sulphur —21,718 tons in the first half of 1958—the U.S. share of the United Kingdom market declined to 69% compared with 82% in the same period 1958. The significance of this change was lessened because of the increased level of imports.

SULPHUR IMPORTS

	1st half 1959	*1st half 1958*
France	21,718	128
U.S.A.	115,309	122,571
Mexico	29,746	27,079
Others	—	71
	166,773	149,849

The average import value was £10 17s. 10d. per ton, a decrease of £1 1s. 0d. per ton compared with the corresponding period in 1958.

Pyrites imports of 96,800 tons were 5½% less than the quantity imported in the first half of 1958. Cyprus further strengthened her position as the United Kingdom's principal supplier of pyrites and accounted for nearly four-fifths of the total. The tonnage of Bolidens concentrates imported from Sweden advanced to represent about 8½% of the total whereas Spain, whose share of the market had shrunk to little over one-quarter of the United Kingdom imports in the first half of 1958, was this year called on to supply only 11%. Small shipments of Avoca pyrites concentrates from Eire were also in evidence.

PYRITES IMPORTS

	1st half 1959	*1st half 1958*
Cyprus	76,052	59,390
Ireland	1,257	320
Canada	—	10,825
Spain	10,628	27,187
Portugal	—	709
Sweden	8,970	4,298
Total	96,807	102,729

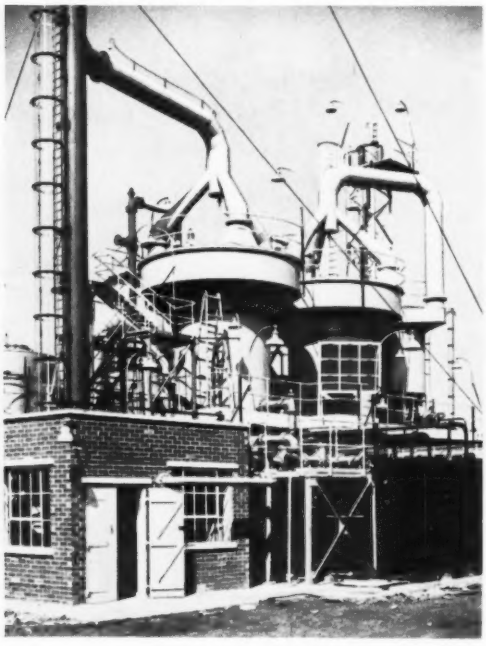
The average import value decreased to £5 6s. per ton from £6 5s. in the same period 1958 due to reduced f.o.b. prices and the continued low level of ocean freights.

Sulphuric Acid

During the first six months of 1959 production of sulphuric acid advanced 5½% compared with that in the first half of 1958 to reach a new peak of 1,204,513 tons (100% H_2SO_4). In the months January to March 1959 acid production was virtually identical with that in 1958; the advance in acid output of some 61,000 tons being attributable to the sustained level of operations in the second quarter when normally production falls. The output of sulphuric acid was based on the use of various raw materials in the following proportions :—

	1st half 1959 %	*2nd half 1958* %	*1st half 1958* %
Elemental Sulphur			
Imported brimstone	37½	35¼	34¼
Recovered H_2S & Filter Cake	6¼	6¼	5
Sulphur in :—			
Pyrites	18	18¼	21
Spent Oxide	12½	13¾	15½
Anhydrite	19	20½	19
Zinc concentrates	6¾	6	5¼
	100	100	100

The greater proportion of brimstone acid is attributable to new plant as well as to the intensive employment of the existing installations. The new plants which came on stream during the period under review included the last of those commissioned when Government control ceased and sentiment, coupled with a rapidly easing world brimstone supply position, favoured expansion based on brimstone acid. During the early part of the year the new plants of Fisons at Immingham, British Titan Products Co. Ltd. at Grimsby, Laporte Titanium Ltd. at Stallingborough and Cowburn and Cowpar at Trafford Park, Manchester, had added 190,000 tons annually to brimstone contact acid capacity. In June, Associated Chemicals Ltd. brought on stream a 100 tons per day brimstone acid plant built by Power-Gas Corporation and this substituted an older pyrites acid installation. Laporte Titanium Ltd., thanks to new plant, were able to reduce their calls on Laporte Acids Ltd., who, in consequence rationalised operations at the Hunslet works, near Leeds, where much older and often uneconomic plant including pyrites and spent oxide furnaces and lead chambers, became redundant. These were only some of the plant closures and instances of under employment of installation using pyrites and spent oxide which caused the decrease in the tonnage of acid produced from these raw materials. As announced by the new Chairman of Blythe & Company, the fate of the BASF turbulent layer pyrites roasters at the Hapton plant of the company's subsidiary, is in the balance pending consultant's advice. There is, however, little doubt that in the present state of acid supplies in the North West, its prosepcts of economic employment are meagre. In the by-product acid sector the new 35 tons per day sludge acid plant of British Petroleum at the Kent oil refinery is operating satisfactorily; the use by British Titan Products Co. Ltd. of copperas—a by-product of titanium dioxide manufacture—is at present being evaluated in full-scale sulphuric acid manfacture. A similar process sequence is to be employed by the Imperial Smelting Company for acid manufacture from spent steel pickle liquor from a number of South Wales mills which is due to start later this year.



Associated Chemicals Ltd. General view of the recently completed 100 tons per day contact and plant at Eaglescliffe built by the Power-Gas Corporation.

During the first half year useful plant capacity was 2.9 million tons 100% H_2SO_4 of which 81.1% was employed. This does not yet fully reflect all the new plants which had come on stream and end of year capacity data will further emphasize the present trend of the growing proportion of contact acid which now represents 82½% compared with 77½% in the first half of 1958.

Sulphuric Acid Consumption

Nearly 6% more than in the last half year of 1958, consumption of sulphuric acid during first six months of this year of 1,218,701 (100% H_2SO_4) was the highest on record. Usage was particularly strong in the first quarter, primarily as the result of heavy demand from fertiliser manufacturers and improvement in the rayon and pigments industries. The decline of 2% in the second quarter reflects little more than seasonal fluctuations.

The Industry consumption pattern was as follows:—

	000 tons (100% H_2SO_4)		
	1st half 1959	*1st half 1958*	*% change*
Fertilizers	445	426	+ 4.7
Chemicals	146	141	+ 3.5
Titanium Dioxide	185	161	+ 14.9
Rayon & Transparent Paper	122	127	− 3.9
Metallurgy	60	62	− 3.2
Oil Refining	30	25	+ 20.0
Dyes	45	39	+ 15.4
Soaps and Detergents	63	58	+ 8.6
Plastics	22	20	+ 10.0
Miscellaneous	101	93	+ 7.5
	1,219	1,152	+ 5.8

Quantitatively lower but nevertheless important changes were recorded in the following industries:—

	CHANGE	
	000 tons H_2SO_4	*%*
Superphosphates	+ 27.8	+ 10.2
Titanium dioxide	+ 23.9	+ 14.8
Ammonium sulphate	− 15.6	− 10.2
Sulphates of copper, nickel	+ 7.6	+ 95.0
Dyestuffs and intermediates	+ 6.5	+ 16.5
Rayon	− 5.0	− 3.9
Soaps and Detergents	+ 4.5	+ 7.8
Oil refining	+ 4.2	+ 15.8
Plastics	+ 1.7	+ 8.4
Bromine	+ 2.3	+ 4.0
Hydrochloric acid	− 1.7	− 6.2
Oils	− 1.6	− 29.2

Non-Acid Sulphur

Consumption of non-acid sulphur in the first half of 1959 totalled 50,100 tons, an increase of 6% over the corresponding period last year. Improved activity in most sectors of the sulphur industry made notable contributions but the bulk of this advance is due to the recovery of the man-made fibre industry. Carbon disulphide recovery facilities at Courtaulds' Greenfield plant* which came on stream in March affected net demand and prevented a more impressive statistical recovery of overall non-acid sulphur usage which would more accurately have reflected the tenor of the industries' activities. The rubber industry, meeting the booming tyre demand but losing more hard rubber outlets to the plastics industry, expanded its sulphur requirements. Demand from the textile industry advanced, the production of sulphites and sulphur dioxide use rose seasonally in food manufacture as well as in several industrial applications.

Summary

Although the higher rate of industrial activity resulted in improved acid demand, there exists much unused capacity and sulphuric acid remains in easy supply. There is in consequence keen competition accentuated by the availability of supplies from sources which are not usually suppliers. The expansion in the titanium industry which is estimated to have installed production capacity of 350,000 tons sulphuric acid and 100,000 tons titanium pigment and which has been the fastest growing sector of the U.K. acid industry for the past six years appears to have completed its programme of expansion. The fertilizer and chemicals industries also appear to have no plans for additional capacity and only the installation of a new 50,000 tons anhydrite acid plant by Solway Chemicals, to meet the expanding needs of its parent Company for phosphoric acid and detergent intermediates, stands as a major project awaiting completion. In this respect the situation in the United Kingdom is no different from that on the Continent. When it comes to acid manufacturing costs and raw materials costs, however, all similarity ceases. The divergence is particularly strong in respect of the latter, attributable to much higher transport costs. Unsatisfactory port facilities notably slow turn round and high stevedoring charges, place the United Kingdom sulphur user at a severe disadvantage. The dependence of this country on competitive production in all industrial sectors, makes it all the more important, now that international marketing arrangements and groupings are making a growing impact on the economies of W. Europe, that the U.K. sulphur industry should aim to remove these handicaps as quickly as possible. As conventional means do not seem to offer an early remedy under prevailing conditions, the U.K. industry should aim for unorthodox solutions which might well be found in the adaption of U.S. experience in long distance liquid sulphur movement and bulk distribution.

* For further details see page 26

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"We view the future with complete confidence. We are firmly decided to supply to our customers a primary material under fully competitive conditions."

A. de Torres Espinosa, Managing Director.

THARSIS

" We are determined that Pyrites will be competitive with any sulphur-bearing materials, and we are confident of the support of the Spanish Authorities."

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PYRITES...

A source of sulphur which is assured, stable — and competitive

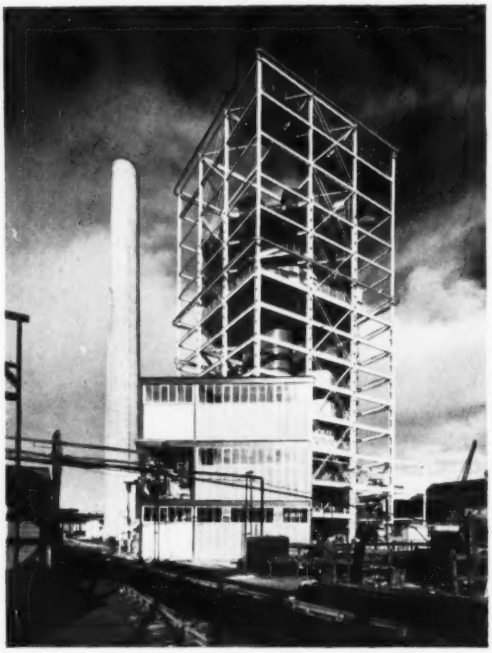
For over 80 years, the RIO TINTO and THARSIS mines in Spain have supplied Pyrites; and their known reserves are unrivalled.

Courtaulds recover Carbon Disulphide

AT THE GREENFIELD WORKS, situated near Holywell, North Wales, and the largest viscose rayon staple plant in the world, Courtaulds Ltd. have recently completed facilities to recover substantial quantities of carbon disulphide from factory exit gases. Since 1936, when the works were first commissioned, the latest equipment and processing techniques have been incorporated to improve the economics of manufacture and the construction of these new recovery facilities at a cost of £500,000 is in keeping with this policy. Although the concentration of chemicals in these exit gases from rayon factories is low compared with many other industries, Courtaulds have spent nearly £500,000 in the last four years on fume scrubbing plant, quite apart from the cost of the new CS_2 recovery plant. Working in conjunction with this fume scrubbing equipment, the new recovery plant removes an unusually high proportion of the CS_2 from the exit gases, thereby considerably reducing air pollution.

The plant is an entirely new development in CS_2 recovery and is believed to be the first large-scale unit to be installed in a rayon factory anywhere in the world; it is expected to recover more than two-thirds of the total CS_2 used in the production unit, a higher proportion than has previously been achieved in the rayon industry. The recovery of CS_2 is a new application for the very large "fluidised" active carbon beds which are the main technical feature of the project. It may also be possible to apply this to the recovery of solvent vapours from air or gas streams in other industries.

Of the two main gases, hydrogen sulphide and carbon disulphide, evolved in viscose rayon manufacture, H_2S as such is of no further use in rayon production. Where the concentration is sufficiently high it is removed from the factory exit gas stream by fume scrubbing plant to avoid polluting the atmosphere but as yet recovery as brimstone or sulphuric acid has not proved economical. CS_2 on the other hand, the principal chemical used for making the soluble cellulose derivative from which rayon fibres can be extruded, is removed during and after the extrusion process. A considerable portion is released as a gas which is drawn into the factory exhaust stream, the concentration remaining dependent on the type of filaments being spun. Research into the possibilities of recovering major quantities of CS_2 was intensified by Courtaulds ten years ago.



General view of the plant for recovering carbon disulphide from exit gas at Greenfield, N. Wales.

The work was given impetus by world sulphur shortage, by the heavier weights of fibre being spun, as a result of increased productivity and by the growing national need for reducing air pollution.

Laboratory-scale investigations were followed in 1954/55 by the construction of a medium-sized pilot plant at the company's Coventry rayon factory. The full-scale CS_2 recovery plant was authorised in 1957 and completed in May 1959. It is now in operation at one of the Greenfield works' two production units.

Designed by Courtaulds Chemical Engineers and by the Engineering Division, it is a steel structure 170 feet high containing a large vertical duct, an adsorber, a stripper/dryer and carbon circulating and regeneration systems. The CS_2 laden gas is blown up the large vertical duct into the adsorber where it fluidises several beds of layers of active-carbon which adsorb the CS_2. The carbon is continuously moving across each tray and downwards from tray to tray into the stripper/dryer which removes the CS_2 by steam. The CS_2 is condensed and passed to a storage tank ready for return to the viscose factory. The active-carbon continues to circulate back to the adsorber except for a fixed proportion which is separated for treatment to remove any minor impurities, whereafter it is returned to circulation. The plant is continuous and fully automatic, incorporating extensive use of indicating and recording apparatus. Only two men per shift are required for supervision.

The scaling-up of the project was a difficult chemical engineering task, owing to the unusual nature of the process conditions. A number of factors such as the volume and velocity of the gas and the size and disposition of the fluidised beds required considerable investigation and development and very careful design, whilst the erection of large vessels to exceptionally close tolerances called for the highest skill.

Total carbon disulphide consumption by viscose rayon, transparent cellulose film ("cellophane") and other uses in the United Kingdom is at present at an annual level of 60,000 tons and it is estimated that the new plant could promote an annual saving up to 8,000 tons carbon disulphide. Depending on the economics of this type of plant it is estimated that potential recovery in the United Kingdom could rise to 20,000 tons annually. The intensive competition which the rayon industry meets throughout the world points to the increasing application of economy measures of which there is already evidence in several major producing countries.

Sulphur in Italy

THE INABILITY of Italian sulphur to compete in export markets at world price levels caused a severe contraction of activity during 1958 and total output was only 157,580 tonnes. Although during the first half of this year the level of exports improved, production of fused sulphur contracted further and amounted to 61,528 tonnes. Of this tonnage, about one-quarter originated from the Mainland, a similar proportion as in 1958.

The high level of exports during the first six months of this year is attributable almost exclusively to the shipment of nearly 8,000 tonnes of sulphur to Egypt under the provisions of a bilateral trade agreement between the two countries. Total exports as detailed below amounted to 26,792 tonnes compared with 31,558 tonnes during the whole of 1958.

Contrary to expectations, the domestic market during the first half of this year deteriorated, and whereas in 1958 it consumed 97,906 tonnes, itself a reduction on previous years, this half year only 43,082 tonnes were delivered. Refining plants and carbon disulphide manufacture remained the principal consumers, but in both sectors, notably the former, substantial reductions occurred.

The combined effect of lower production and the slight improvement in exports caused the level of stocks to decline some 7,300 tonnes to 226,008 on the 30th June, 1959.

An important novel feature of the Italian sulphur industry is the manufacture of sulphur concentrates containing 85% sulphur. These operations advanced from 5,347 tonnes in 1958 to 14,601 tonnes during the first six months of this year. In addition, the industry supplied the customary quantity of sulphur ore (approx. 20%S for grinding and a growing volume for the manufacture of sulphuric acid. Once the sulphuric acid plants of Società Industriale Catanese at Priolo, and of Rumianca S.p.a., near Pomezia and Rome, have been completed, the level of sulphur ore deliveries can be expected to approach one million tonnes, and so play a leading part in Italian sulphur industry.

For the time being, legislation prevents the import of sulphur and as yet no deliveries of competitive recovered sulphur from France

have entered the country. Some of the hardship of the viscose rayon industry, which has been obliged to purchase domestic sulphur at the official price of 48,800 lire per tonne f.o.r., is mitigated by a Government subsidy, but there is little doubt that if import restrictions were removed the majority of Italian brimstone consumers would find themselves unable to continue giving their custom to domestic suppliers. In the meantime, Ente Zolfi Italiani is sparing no effort to assist the industry in rationalising mine production and establishing competitive outlets for the industry's products.

Crude Sulphur Exports

	1958	Jan.-June 1959
Austria	0.5	0.8
Czechoslovakia	—	3.0
Egypt	—	8.0
France	21.9	8.6
Greece	0.6	—
Morocco	3.1	2.0
Israel	1.0	—
Portugal	1.1	0.8
Tunisia	2.0	0.8
Jugoslavia	1.3	2.5
Total	31.6	26.8

Domestic Sales of Crude Sulphur

	1958	Jan.-June 1959
Refining	45.1	17.6
Carbon Disulphide	33.3	14.7
Cellulose	12.4	5.5
Polysulphides	2.5	1.5
Others	4.6	3.8
Total	97.9	43.1

Sulphur Production

	1958	Jan.-June 1959
Crude Sulphur	157.6	61.5
Sulphur Concentrate	5.3	14.6

Fig. 7. Italian sulphur production, domestic sales and exports in thousand tonnes.

SULPHURIC ACID IN INDIA

THE RISING LEVEL of India's general industrial activity in recent years has been due in no small measure to the planned expansion of the chemical industry and agricultural output under the Five-Year Plans. Even by Western standards, great strides have been made in the introduction of heavy industries, notably steel and basic chemicals for agriculture. In order to avoid placing too much strain on the economy and to mitigate foreign exchange difficulties resulting from excessive plant procurements from abroad, considerable detail has been applied to the phasing of the various projects; this policy has not been wholly successful and there have been shortages of heavy chemicals because of delays in the erection of some plants.

Sulphuric acid and chemical fertilizers are amongst these industries and although production has risen substantially its rate of growth is not so fast as was anticipated under the provisions of the Second Five-Year Plan which ends in 1961. In the case of sulphuric acid, the claims on scarce foreign currency resources are twofold : the cost of procuring plant from abroad and of importing increasing quantities of brimstone on which almost the entire acid production is based. Fertilizers are the largest acid using industry although their manufacture does not dominate the sulphuric acid use pattern. Amongst important consumers are the textiles, iron and steel and chemical industries which have a large growth potential. With the rapid development of the Indian chemical industry there are a large variety of small users such as bichromates, hydrochloric and nitric acids, mineral oils, aluminium sulphate, metal refining, organic chemicals, etc., with a consumption estimated at 60,000 tons.

Brimstone Consumption

During 1958 it is estimated that some 120,000 tons of brimstone were consumed, about 10% more than in the previous year. Of this total 80% was consumed in the manufacture of sulphuric acid, the remainder being consumed by the non-acid sector for the manufacture of CS_2, SO_2 and for processing into agricultural sulphurs, insecticides and sulphites. This record consumption of brimstone for acid manufacture resulted in the production of some 227,000 tons of sulphuric acid (100% H_2SO_4), 31,000 tons more than in the previous year, and the number of acid plants in operation increased by 4 to 40. Expansion in the sulphuric acid industry has only been evident

since 1953 when the provisions of the country's First Five-Year Plan were beginning to materialise. Under the Second Five-Year Plan it is planned to raise installed capacity to an annual level of 600,000 tons (100% H_2SO_4)—capacity at the end of 1958 is estimated at 300,000 tons—and even this tonnage is thought by some planners to be too low. Licences have been granted for the erection of new sulphuric acid plants and extensions to existing plants which would increase current capacity by 330,000 tons (100% H_2SO_4) per annum. Already a few companies have placed contracts for erection of acid plants and construction work has commenced while several others are unable to obtain the necessary foreign exchange needed to commence their projects.

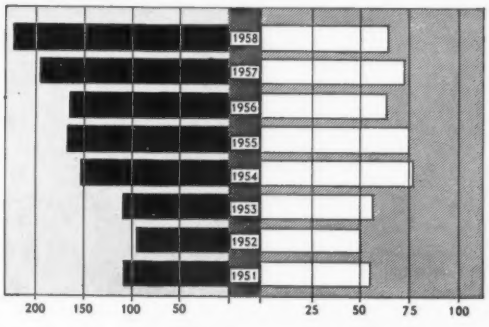


Fig. 8

The four new acid plants completed in 1958 were the 25 tons per day plant for the Bihar Government at Sindri, a plant of similar capacity for Gwalior Rayon Silk Manufacturing Co. Ltd. at Nagda, a 10 tons per day pot concentration plant for the I.C.I. explosives plant at Gomia and India's largest installation, the 160 tons per day (100% H_2SO_4) plant of Fertilizer and Chemicals (Travancore) Limited.

Fertilizers

In contrast to other countries with primarily agricultural economies, in India fertilizers do not take up the bulk of acid production. This is largely due to the decision to produce nitrogenous fertilizers wholly on the basis of indigenous resources—at Sindri some 350,000 tons ammonium sulphate is manufactured by the reaction of ammonia, carbon dioxide and gypsum—and to the past low level of phosphate fertilizer use. Fertilizers are estimated to consume about 100,000 tons sulphuric acid — 41% of total use — the remainder being consumed in a wide variety of industries.

The most significant developments are taking place in the superphosphate industry and will account for a major expansion in acid requirements (300% by 1961). The increase in phosphatic fertilizer use has been stimulated by the education of farmers to their uses and the fact that soils are deficient in phosphate. Superphosphate production in 1958 totalled 169,000 tons from 14 producing plants, which are working at less than half their rated capacity. Under the Second Five-Year Plan the following licences have been granted for phosphatic fertilizer plants in conjunction with integrated acid units:—

	Capacity in tons per annum	
	Super-phosphate	*Sulphuric acid*
Pioneer Chemicals Industries (India) Ltd., Nagpur	36,000	16,500
Hyderabad Chemicals & Fertilizers Ltd., Secunderabad	24,300	8,100
Jayshree Chemicals & Fertilizers Ltd., Calcutta	33,000	16,500
Western India Chemicals, Bombay	33,000	16,500
Dharamsi Morarji Chemical Works, Bombay	14,400	16,500
Andhra Fertilizers (Pvt) Ltd., Madras	50,000	16,500
Krishna Industrial Corporation, Madras	50,000	16,500
Adarash Chemicals & Fertilizers, Navsari	33,000	16,500

In adition to these licences, the *Hindustan Heavy Chemicals Ltd.* have also received a licence to erect a superphosphate plant with an annual capacity of 5,400 tons and acid requirements will be met from the company's Leonard-Monsanto plant, installed in 1945, which has a daily capacity of 10 tons (100% H_2SO_4). *Shaw Wallace & Co. Ltd.* are at present undertaking a major expansion at their works at Avadi and are installing a 50 tons per day acid plant to supplement their existing plant which has capacity of 20 tons acid per day. Their superphosphate plant is based on a Broadfield continuous den and although it currently produces 23,000 tons superphosphate, it has a capacity of 60,000/70,000 tons,

adequate to consume all the additional acid to be produced. The fertilizer project of *Dharamsi Morarji Chemical Co. Ltd.*, reported to have been completed this June, has involved the erection of a 50 tons per day contact acid plant and dismantling the company's old chamber plant and a small 10 tons per day contact unit. At the same time superphosphate production capacity was expanded 50% to 120 tons per day. It is believed that this company's plant to produce 10 tons per day triple superphosphate is the only installation of its type in India.

The new sulphuric acid plant at Sindri is integrated with a superphosphate plant (annual capacity 60,000 tons) but owing to difficulties in procuring raw materials, production of superphosphates since April 1958 has been at a level of about 1,000 tons per month. As installed acid capacity and output is insufficient to meet the company's needs, arrangements exist to take surplus spent acid from the explosives plant at Gomia.

Textiles

The rapid expansion of the viscose rayon industry has augmented the demand for sulphuric acid and several new plants are being built by the industry with integrated acid facilities. *Gwalior Rayon Silk Manufacturing Co. Ltd.*, one of India's largest producers, has been working to capacity and as their present acid supplies from their plant, completed in early 1958, are insufficient to meet their current needs, they have applied for a licence to install an additional 50 tons per day plant, at the same time expanding their viscose facilities. An important new viscose installation is reported to have entered production in May 1959 when the various units built at Kanpur for *Juggilal Kamlapat Cotton Spinning & Weaving Mills Co. (Pvt.) Ltd.* were reported to have been completed. The sulphuric acid plant with a daily capacity of 25 tons was built by the Pan-American Consulting Co. of Reisterstown, Maryland, U.S.A., while the carbon disulphide plant was built by Ing. A. Maurer S.A. Switzerland. The project for *Travancore Rayons* is due to be completed in the latter half of 1959; part of the overall expansion of the company's facilities is the installation of a 50 tons per day acid plant by Chemiebau Dr. Zieren of Cologne. It is of interest to note that a second climbing film evaporator and crystallisation section is to be installed and that the rayon plant incorporates an acid recovery section.

Other developments in the textile sector include the erection of a sulphuric acid plant in W. Bengal for the *Kesoram Cotton Mills* with a daily capacity of 25 tons, while *South India Viscose* are to erect a large new plant at Mettupalayam, Madras. South India Viscose has been formed in conjunction with Italviscose Eastern Trading S.p.A. of Milan for the production of staple fibre and rayon and they are spending about £6½ million on this project. The plant is designed to produce some 8 million lbs. of viscose rayon yarn and staple fibre and integrated facilities will include a 35 tons per day sulphuric acid plant and a 7½ tons per day carbon disulphide plant. It is intended at a later date to install the necessary plant for the manufacture of cellophane which for the time being is imported. Italviscose Eastern Trading S.p.A. is directly connected with Snia Viscosa who will supply all the necessary machinery and equipment for the projected production of staple fibre, which was scheduled to commence this year, but is not now expected until 1960.

Chemicals

In recent years there has been a rapid growth in the manufacture of chemicals. Owing to rising acid demand several small chamber plants—often only with a capacity of one or two tons—were closed, to be replaced by modern contact installations while some plants have been extended and modernised. *Cawnpore Chemical Works,* who require sulphuric acid for the production of heavy chemicals, have been granted a licence to erect a 25 tons per day acid plant at Kanpur in order to meet their increased requirements and make them independent of outside supplies. Plans for a plant of similar capacity have now been finalised by *Atul Products Ltd.*, whose acid needs for the production of sulphur dyes and drugs necessitate oleum facilities. *Kalinga Tubes Ltd.* of Calcutta are experiencing difficulties in obtaining the necessary foreign exchange to erect their 10 tons per day plant and are investigating the possibilities of obtain-

ing local plant and machinery. The only plant producing titanium dioxide pigments in India is that of *Travancore Titanium Products Ltd.* at Trivandrum in Kerala State. Completed in 1956 the plant has a capacity of 1,800 tons per annum TiO_2 and its acid requirements are met from an integrated unit now being expanded to 100 tons per day (100% H_2SO_4). Construction work has been progressing throughout the year on a plant which will double existing TiO_2 capacity.

D.C.M. Chemical Works. View of the waste heat recovery section of the 75 tons per day acid unit.

Iron and Steel

The rapid expansion of India's iron and steel industry with the completion of the three major projects at Bhilai, Rourkela and Durgapur, will result in a sharp rise in the use of acid for pickling. The steel works at Durgapur, being built by Indian Steelworks Construction Co. Ltd.—a consortium of 13 British companies—includes a sulphuric acid plant with a daily capacity of 60 tons. Built by Simon-Carves of Cheadle Heath, Stockport, it is a standard contact unit and although completed early this year, it is not yet in full production as the steel works are not yet at full blast. The plant is based on brimstone but desulphurisation units at the coke-ovens permit the recovery of H_2S sufficient to produce 4 or 5 tons per day of sulphuric acid. Facilities at the Rourkela steelworks, built by the Germans, include by-product ammonium sulphate and sulphuric acid based on a wet desulphurisation process and capable of producing up to 20 tons per day although total installed acid capacity is 60 tons.

Conclusion

Inevitably the rapid industrial expansion is boosting sulphuric acid requirements. Because of the present lack of indigenous brimstone supplies the Indian Government is exploring many alternatives intended to reduce the dependence on imported brimstone. In conjunction with phosphatic fertilizers, phosphoric acid produced by the electrothermal furnace method instead of sulphuric acid is a subject of investigation, but to date the economics have not proved to be sufficiently attractive to encourage early substitution. An important project is at present under consideration to erect a sulphur recovery plant based on smelting pyrites by the Orkla process at a daily rate of 100 tons. If developed it will form a useful source of domestic brimstone but will account for less than 10% of India's requirements. There has been no co-ordinated development in the use of other domestic sulphur resources such as the use of refinery sludge acids and coke-oven H_2S. At present there is no recovery of by-product sulphuric acid from non-ferrous smelter gas but a project has been approved by the Indian Government for the Metal Corporation of India Ltd. The company is to erect a zinc smelter at Udaipur, Rajahstan Province, and the plans include provisions for a by-product sulphuric acid plant.

It may be expected that Indian sulphur imports will continue to rise over the next few years as the demand for sulphuric acid increases for superphosphate, textiles and iron and steel manufacture, although all sectors of the economy are expected to show a growth in acid consumption. It is estimated that India's sulphur requirements will rise to about 250,000 tons by 1962, nearly all of which will be imported as the overall supply picture is not likely to be affected by indigenous sulphur production.

The Sulphuric Acid Bounty in Australia

THE REPORT of the Tariff Board on the Sulphuric Acid Bounty has been eagerly awaited by the industry. In his statement in the House of Representatives on the 12th May, however, Mr. McEwen, the Minister for Trade, announced that although the Report recommends new bounty rates for acid produced from iron pyrites or lead sinter gas, designed to encourage further conversion to the use of indigenous materials, the Government has decided that a change of policy is required because of abundant world sulphur supplies. The Tariff Board is to be directed to conduct a fresh inquiry and to recommend rates of bounty " which, whilst not being designed to encourage further conversion, will honour the Government's obligations to the people who have co-operated in the past." Mr. McEwen went on to say that he referred " to the people who have installed facilities to produce or use Australian sulphur-bearing materials, including those who are at present committed to the installation of new facilities." The present Bounty Act and Regulations are to be continued for a further period of one year dating from the 1st of July 1959. In view of the Government's decision, it seems likely that the rate of bounty, which at present depends on the extent to which the Pool price of sulphur falls short of £A20 10s., may in future be calculated from a lower price than this.

At the time of the world brimstone shortage in 1951, the Australian Government, like the governments of so many other countries, decided to try to reduce its dependence on outside sources of sulphur. Many of the indigenous sources of sulphur are more costly to use than brimstone for acid manufacture; and the Government stated that the production of acid from domestic raw materials would be protected from the competition of brimstone acid whenever brimstone could be imported at a low enough price to make the use of local raw materials uneconomic. Hence in 1954 when cheap brimstone became available the Sulphuric Acid Bounty Act was brought in. Initially the scheme applied only to the users of iron pyrites, but by the budget speech of 3rd September 1957 by-product acid from lead smelter gases was also included. At the same time the upper limit of £A600,000 on the total of annual payments was removed. The increasing expense of the subsidy to the government, arising from the lower world brimstone prices as well as from the considerable fall in freight rates of about eighteen months ago, quite apart from the greatly increased volume of acid from the domestic sources in question, no doubt influenced the Government in its change of policy. The high freight rates prevailing at about the time of the Suez crisis had reduced the average level of

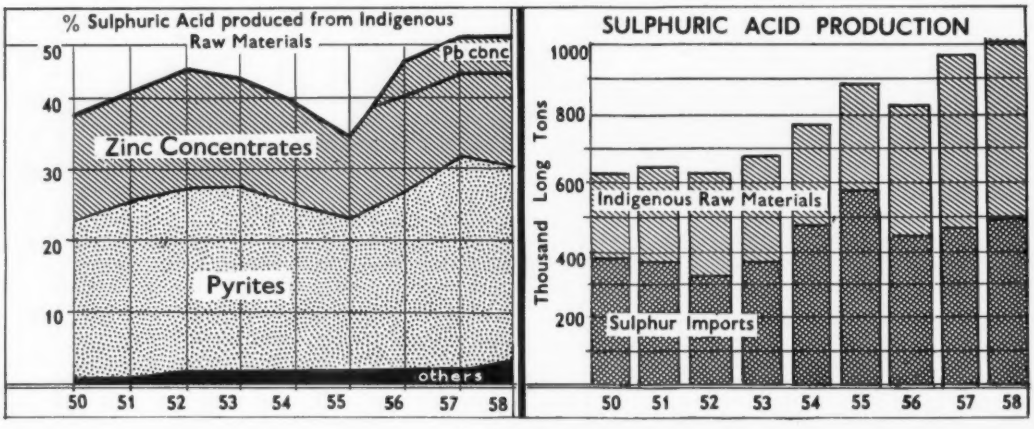


Fig. 9

payments per ton in 1956 and 1957. The figures for the first four years were as follows:—

Financial year ending 30th June	*Total Paid*	*Tonnage on which paid 100% H_2SO_4*	*Average payment per ton*
1955	£A306,305	131,956	£A2. 6.6
1956	£A446,666	236,946	£A1.17.6
1957	£A458,013	276,319	£A1.13.0
1958	£A849,347	370,736	£A2. 6.0

For the half-year ending on the 31st of December 1958, £A652,135 was paid on 183,895 tons of sulphuric acid. It is estimated that the figure for the second half of the financial year will be about £A555,000 on 140,500 tons, making a record sum of approximately £A1,207,000 for the whole year. For the first quarter of the financial year 1958-59 the rate of bounty paid per ton of acid was £A3 4s. 6d., and the rate for the remaining three-quarters was £A3 18s. 6d.

For some years the bounty has been a dominant factor behind the pattern of the Australian sulphuric acid industry. Figure 9 illustrates the change in the proportion of acid made from indigenous sources which the government policy has brought about and shows also the background of overall sulphuric acid production. The proportion of brimstone acid declined slightly from 62% in 1950 to 59% in 1952 owing to the brimstone shortage; total sulphuric acid production rose by 2% in 1951 but fell by 4% in 1952. The subsequent increase in the proportion of brimstone acid over the next three years to the peak level of 64% in 1955 may be attributed to increasing brimstone supplies and to the 43% expansion of overall output. It was not until 1956 that the effects of the bounty became apparent as new plant capacity based on indigenous sources came into operation; at the same time total sulphuric acid production fell by 6% on account of a bad fertilizer year: in 1956 the proportion of brimstone acid declined to 53%. By 1957 the proportion of brimstone acid had fallen to 49%, despite a 16% increase in total sulphuric acid output. For the year following the proportion was approximately the same; and total output rose by only 3%.

The industry's plans for capacity expansion seem to have waited on the Report of the Tariff Board: a high proportion of capacity has been used in recent years; and taking into account that both Geelong and the third plant at Risdon came on stream late in the year, the proportion of capacity used in 1958 is estimated at 95%.

The past official aim of achieving at least 65% sulphur self-sufficiency now seems very remote, although when present plans are completed the level of self-sufficiency might be about 58%. There are two projects in hand, both of which are to be based on indigenous raw materials. In the near future the Sulphide Corporation (Pty.) Ltd. is having a new acid plant built at Cockle Creek which will have a capacity of 250 tons of sulphuric acid per day based on zinc smelter gases. The plant is expected to come on stream in mid-1961. The increase in sulphuric acid capacity is to be used in part for greater acid sales to industry in the Newcastle area, but principally for more extensive superphosphate production to meet the rising demand in New South Wales. Work continues on the contact acid plant of Australian Fertilizers Ltd. at Port Kembla, which is being based on sinter gas obtained from the copper smelter of the Electrolytic Refining and Smelting Company of Australasia (Pty.) Ltd. Recovery of the sulphur content of crude oil is now being practised at two oil refineries, namely at Geelong, and at the Altona Works of the Standard Vacuum Refining Company. While sulphuric acid is produced at Geelong, elemental sulphur is being produced at Altona.*

When these projects have been completed, it is estimated that total capacity will have expanded from the present annual level of 1.15 million tons (100% H_2SO_4) to about 1.36 million tons by mid-1961. Assuming an annual increase in sulphuric acid production of about 4%, the proportion of capacity used would then be only approximately 83%. On account of the proposed change in the bounty further expansion of sulphuric acid capacity is likely to be based for the main part on brimstone.

* For further details see page 47

SULPHURIC ACID IN JAPAN

RARELY HAS the Japanese sulphuric acid industry had to face so many difficulties in one year as those by which it was confronted in 1958. The fertilizer industry, which largely depends for its prosperity on its ability to export, absorbs far more sulphuric acid than any other single use; and in 1958 all imports from Japan were banned from the important market of Communist China. Second in importance is the use of sulphuric acid in the manufacture of artificial and synthetic fibres; and the output of rayon as a whole, and of filament in particular, was severely cut down, in part owing to competition from nylon. World trade was depressed. The Japanese Government pursued a stringent deflationary policy.

Hence it is not surprising that the output of sulphuric acid fell for the first time since 1945. What is more remarkable is that the decline in output should have been as small as 3¼%.

The following table sets out the principal acid consuming industries :—

SULPHURIC ACID CONSUMPTION

000 tonnes 100% H_2SO_4

	1958	*Change* *000 tonnes*	*Change* *%*
Nitrogenous Fertilizers ...	1,869	+ 109	+ 6
Phosphatic Fertilizers ...	830	− 20	− 2¼
	2,699	+ 89	+ 3½
Artificial & Synthetic Fibres	383	− 136	− 26
Inorganic Chemicals ...	222	− 17	− 7¼
Organic Chemicals ...	69	− 11	− 13½
Iron and Steel	89	+ 6	+ 7¼
Petroleum	65	− 7	− 9½
Dyestuffs & Intermediates	36	+ ½	+ 1½
Miscellaneous	281	− 7	− 2½
	3,843	**− 82½**	**− 2**

Although there was a small decline in consumption of sulphuric acid for phosphatic fertilizers, which are generally not quite maintaining their relative position, consumption for nitrogenous fertilizers, in contrast, showed a significant increase. Thus, despite the difficulties of the fertilizer industry, its use of sulphuric acid rose slightly by 89,000 tonnes. An increase of 6,000 tonnes was recorded in the consumption of sulphuric acid for iron and steel, largely for the shipping industry. On the other hand, the consumption of sulphuric acid for artificial and synthetic fibres fell by 136,000 tonnes; and the fall in consumption for inorganic and organic chemicals, petroleum, and miscellaneous uses taken together amounted to a further 42,000 tonnes.

Overall consumption of sulphurous raw materials declined by about 6% by weight of materials. The reduction in the use of iron pyrites (about 9% by weight) and sulphur ore (about 5% by weight), and the increase in pyrrhotite consumption (10% by weight), indicate that the higher sulphur content of pyrrhotite concentrates has partly made up for the significant fall in the lower grade pyrites and sulphur ore intake. The heavy decline in other raw materials refers mainly to spent oxide. Of lesser impact was the consumption of a small amount of sulphur in lead ore, the first instance of lead smelter gases being so used.

SULPHUROUS RAW MATERIALS CONSUMPTION

	1958	*Change* *000 tonnes*	*Change* *%*
Iron Pyrites	1,726	− 175	− 9¼
Pyrrohotite	231	+ 21	+ 10
Sulphur Ore	672	− 35	− 5
	2,629	− 189	− 6¼
Zinc Blende	250	No Change	No Change
Copper Concentrates & Copper Pyrites	228	− 4	− 1½
Others	2	− 1	− 29½
Lead Ore	2	*	*
	3,111	**− 194**	**− 5¾**

* Not previously used

A comparison of the consumption of zinc and copper ores with the acid actually produced from them yields the conclusion that there was a considerable increase in efficiency in recovering the sulphur content of the smelter gases, mainly attributable to the greater use of modern plant. The closing of several old chamber plants in 1957 reduced the percentage of chamber acid to 38, part of a long-term

trend which continued in 1958 when chamber acid accounted for only 34% of total output. This trend towards a greater proportion of contact acid is illustrated in Fig. 10.

SULPHURIC ACID PRODUCTION—1958

000 tonnes 100% H_2SO_4

From:	*Sulphur ores*	*Copper ores*	*Zinc ores*	*Total*
Chamber	1,152	94	40	1,286
Contact	2,016	293	207	2,516
Total	**3,168**	**387**	**247**	**3,802**
1957				
Chamber	1,298	143	45	1,486
Contact	2,045	210	191	2,446
Total	**3,343**	**353**	**236**	**3,932**
Percentage Change				
Chamber	− 11¼	− 34½	− 11½	− 13½
Contact	− 1½	+ 39½	+ 8	+ 2¾
Total	**− 5¼**	**+ 9½**	**+ 4¼**	**− 3¼**

In 1957 the Mitsubishi Metal Mining Company Ltd. installed at Naoshima a new Lurgi contact plant with a capacity of 220 tonnes a day, making the company's daily capacity 383 tonnes. The plant treats copper concentrates from the Atlas Mining Consolidated and Development Corporation in the Philippines. Also importing from the Philippines is the Nippon Mining Company, which buys copper ore from the Philippine Mining and Development Company. Following the completion of the first phase of its development programme, the company now has three Lurgi contact plants, one at Hatachi and two at Saganoseki, with a total daily capacity of 520 tonnes.

Two sulphuric acid plants came on stream in 1958. The Toyo Gas Chemical Industries Limited has one new plant built by Monsanto at their Niigata works with a daily capacity of 105 tonnes, treating iron pyrite in a Herreshoff furnace. The Befu Chemical Industries Company has a new plant built by the Chemical Construction Corporation with a daily capacity of 180 tonnes, consuming iron pyrite in a fluidised bed roaster. The company's total capacity is now 380 tonnes daily. Both plants produce contact acid which is used for the manufacture of ammonium sulphate.

The total capacity of the Japanese sulphuric acid industry, which has been increasing for some years, in 1958 reached the record level of about 13,600 tonnes a day of which approximately 80% was utilized.

Although it appears that no new plants are under construction in 1959, the Furukawa Mining Company Ltd. is considering doubling the capacity at its Ashio mine and smelter, which is at the moment 210 tonnes per day. If the company were to decide to do this its total capacity would be increased from 298 tonnes per day to 508 tonnes per day. The Ashio plant, which was built by Monsanto, produces contact acid; the smelting process used is that developed by the Outokumpu Company of Finland and the existing capacity is 1,300 tonnes of blister copper monthly.

There is some uncertainty about the future of fertilizer exports both on account of the political attitude of the government of Communist China and the aim of early self-sufficiency in several of the importing countries. One factor influencing the sulphuric acid demand will be the extent of conversion to

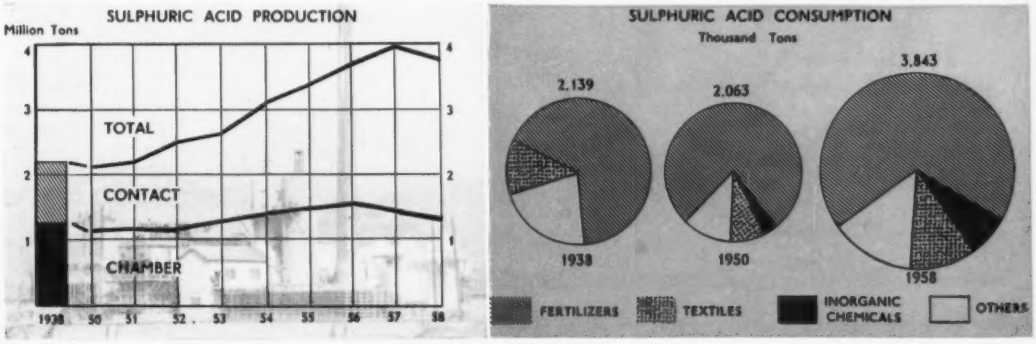
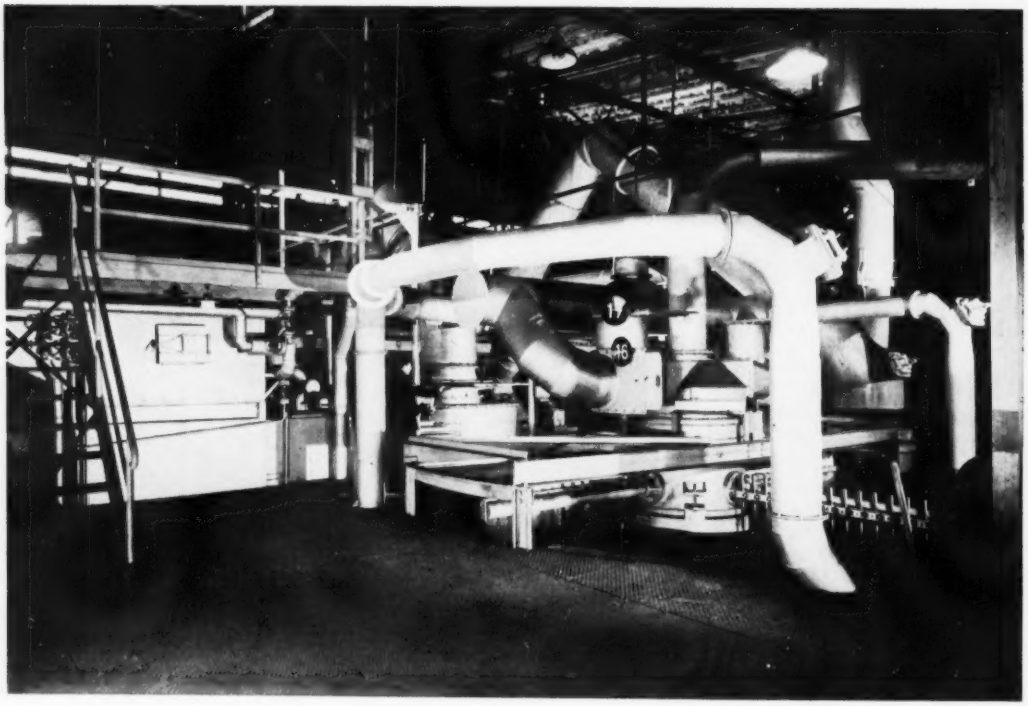


Fig. 10

urea manufacture. It is doubtful whether the demand for sulphuric acid in the iron and steel industries will continue to rise in 1959 on account of the reduction in shipyard activity. On the other hand, a higher level of economic activity is likely to increase the sulphuric acid demand of the other industries which showed a significant decrease. While the rayon industry will not reach its previous peak, it is probable that there will be a re-adjustment to a level of output higher than that of 1958. The sulphuric acid demand for petroleum, organic and inorganic chemicals and miscellaneous uses is also likely to increase. It now appears that the output of sulphuric acid will increase slightly in 1959, but that the industry will still be producing below capacity. Japan remains the largest producer of sulphuric acid after the United States and U.S.S.R. and there is no reason to suppose that this relative position will show any change in the forseeable future.

THE HUMBOLDT PYRITES FURNACE WITH HEAT RECOVERY

IN THE development of new features and new designs of pyrites roasting furnaces in recent years, the recovery of waste heat, prompted by economic necessity, has attracted special attention. Flash roasters and subsequently fluidised bed furnaces achieved a progressively greater output per unit, savings in floor space, and above all permitted a large proportion of the exothermic heat of the decomposition of pyrites to be recovered. In contrast with the conventional hearth roasting furnaces and cylindrical kilns, which have throughput capacity of 80-100 kg. per m^2 of roasting area per day, this factor rises to 1,100 kg./m^2 for flash roasters and to 9,600 kg./m^2 for fluidised bed furnaces. This concen-



A pyrites roasting installation, showing the drying hearth and the pipework for cooling air and gas recirculation. Waste heat boiler on left.

tration facilitates the speedy removal of heat without the necessity of large-scale equipment.

In hearth furnaces and kilns, without the use of special installations, approximately 0.8 tons of steam per ton pyrites is recoverable by utilising the heat of waste gases; quantitatively this compares unfavourably with other facilities, as normally fluidised bed furnaces or brimstone burners provide steam suitable for electricity generation at a rate equivalent to 1.3-1.5 tons per ton of pyrites of 48-50% content. Probably the main stimulus towards achieving comparable results in hearth furnaces was the unfavourable process conditions in fluidised bed roasters for obtaining from arsenical pyrites an iron residue that is substantially free from arsenic. Residues treatment, which plays an exceptionally important part in Germany's sulphuric acid industry, has been developed on the basis of Spanish and Portuguese arsenical pyrites and the medium for obtaining residues with the most satisfactory chemical and physical properties have been hearth burners and kilns. The development of heat recovery in this connection is of outstanding importance to the pyrites industry as a whole. Several notable plant makers in Germany, including Lurgi Gesellschaft für Chemie und Hüttenwesen m.b.H. and Chemiebau Dr. A. Zieren, have been engaged on the problem and have succeeded in developing a satisfactory solution.

Probably the most advanced as regards practical application are the furnaces of Klöckner-Humboldt-Deutz of Cologne which provide for the recovery of waste heat as well as direct heat exchange. The waste-heat utilisation is effected in a double-tube boiler and results in a substantial increase in efficiency of the exothermic pyrites roasting process. Moreover, it also causes roaster gases to be cooled—a pre-condition for the application

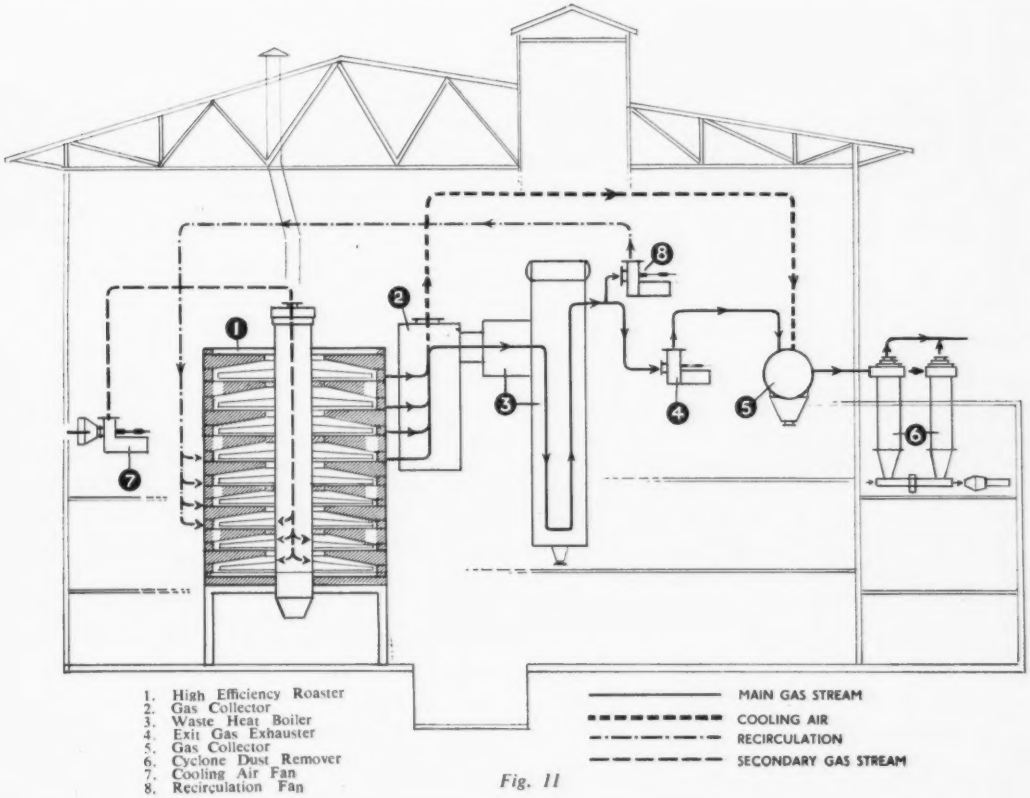


Fig. 11

of the direct heat-exchange process. The direct heat exchange or the roasting-gas circulation process developed by Humboldt and introduced into the industry consists in a positive return of part of the roasting gases—cooled down to approximately 350°C in the waste-gas boiler—to the middle hearths of the furnace. The resultant cooling of the furnace in connection with other measures results in the following advantages compared with the conventional working conditions:—

1. Essential increase of the specific roasting efficiency and thus of the furnace throughput without affecting the SO_2 concentration of the waste gases.
2. Better utilisation of the heat of the waste gases and thus increase of the specific steam generation.
3. Compensated temperatures of the individual hearths, good roasting, even with a high throughput, and simplification of operation.

The roasting gas is withdrawn from the top four hearths by a gas collecting pipe and is passed to the boiler without any previous dust removal. As there are no cyclone collectors between the roasting furnace and the boiler the dust recovery in the boiler is naturally higher. The roasting gas enters the boiler at a temperature of about 810°C and leaves it at a temperature of about 330°C. The front part of the boiler is designed as a superheater. By that means the steam is heated to 375°C. Air regulation is effected by an adjustment of the slide valve at the cooling-air fan. The entire cooling air for the rabble arms is blown directly into the furnace. The circulating gas volume required depending on the sulphur content and on the throughput is also controlled by actuating a slide valve at the circulation air fan. In this way the concentration of the roasting gases can be adjusted as required within wide limits. Steam generation can also be increased by raising the waste gas concentration. This is done by reducing the cooling air volume and increasing the circulating gas volume. With an increase of the total gas volume there is a decrease in the volume of waste gas proper and consequently also that of heat losses. The resultant energy is used in the boiler, whilst roasting efficiency is not adversely affected since the pre-heated combustion air is carefully controlled. By cooling the roasting gases, temperature peaks in excess of 900°C are removed and the temperature of about 900°C is distributed over about five hearths instead.

Figure 11 shows a nine-hearth Humboldt furnace. The following table indicates significant operating particulars obtained with Meggen Fines pyrites containing about 40% S.

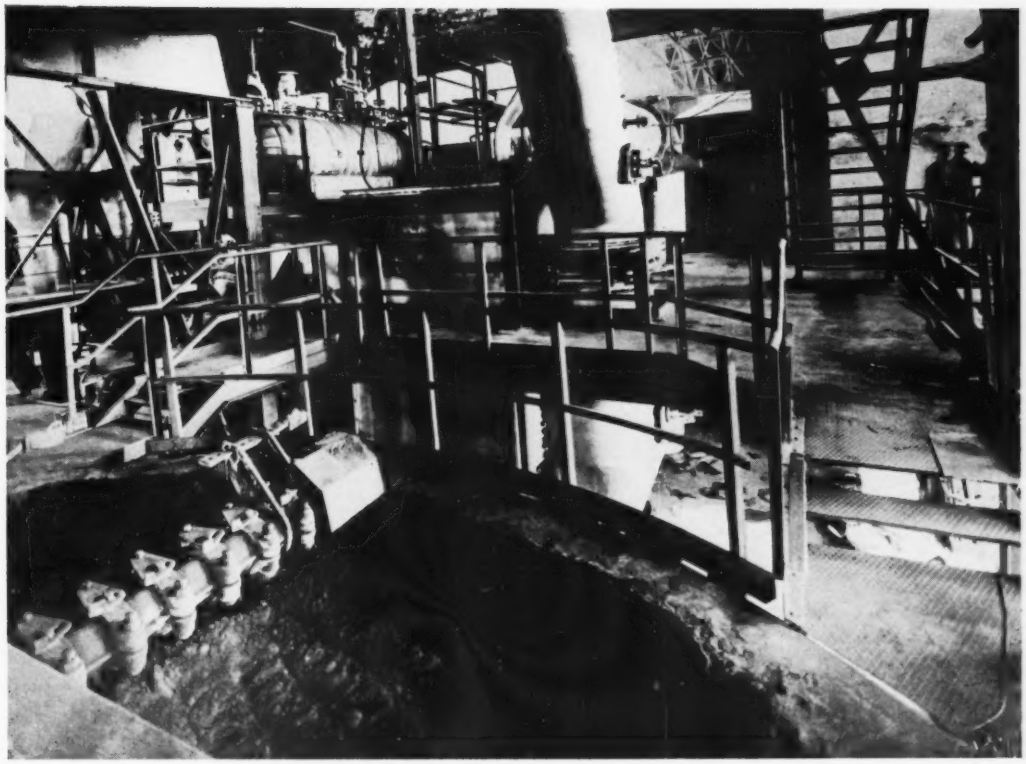
Comparison of corresponding operating data

	Without circulation	With circulation
Throughput (Meggen fine pyrite)	Max. 62 tons/day	75 tons/day
Circulating gas volume	—	3,000-4,000 std.m³/hr.
Cooling air volume	6,000 std.m³/hr.	6,700 std.m³/hr.
Steam generation (40 atm.g. 360°C)	1,830 kg./hr.	2,630 kg./hr.
Steam/ton Sulphur (40 atm.g. 360°C)	1950 kg./ton S	2,330 kg./ton S
Roasting (% S in the cinders)	below 5% S	below 5% S
Concentration of the waste gases	7-9 vol. % SO_2	7-9 vol. % SO_2
Temperature 1st stage	620°C	670°C
Temperature 5th stage	970°C	930°C
Temperature 9th stage	750°C	800°C

The high zinc content—10%—in the Meggen Fines pyrites accounts for the relatively high sulphur content in the residues. The bulk of European pyrites supplies have 48-50% sulphur and appreciably lower non-ferrous metals constituents; and with these steam generation per hour and per ton of pyrites is higher.

Three furnaces of the above type have been operating satisfactorily for over two years by Chemische Industrie G.m.b.H. of Bochum, each with a daily capacity of 70-75 tons Meggen Fines pyrites. Six similar furnaces are under construction in Western India, and when on stream next year will have daily capacities of 50-60 tons pyrites of up to 48% sulphur content. Two larger furnaces, with 11 hearths and with a guaranteed daily throughput of 70 tons pyrites are under construction and due to come on stream early in 1960 at the Leverkusen works of Farbenfabriken Bayer.

In Spain and Italy Humboldt multiple hearth roasting furnaces with waste heat utilisation are installed for zinc blende roasting at a daily rate of 55-60 tons of about 30% S material. There are at present several plants, based on the use of pyrite and zinc blende, at the planning and construction stage; all are equipped with waste heat boiler, roaster gas dust collection and direct heat exchange of the circulating roaster gas.



General view of a zinc blende roasting unit. In the foreground is the drying hearth of the multiple-stage furnace and in the background, the waste heat boiler.

In contrast with pyrites roasters, the blende furnaces have fundamentally different gas circulation as in the case of the lower grade sulphurous materials the excess heat in the upper hearths is transferred by blowing in roaster air, i.e., the heat exchange in blende furnace is effected by blowing in roaster air pre-heated in a recuperator. These are installed in the exit gas stream ahead of the waste heat boiler and dust extraction cyclone. In pyrites roasters heat exchange is not achieved by way of recuperators, but as indicated, by returning to the centre hearths a part of the roaster gases which had been cooled in the heat exchanger. Heat from the waste gases offers economic advantages as it yields 500 kg. steam per ton of blende and 1,000 kg. steam per ton of pyrites. This contrasts with the energy requirements of a furnace which is 40 kw. including power for fans and labour needs which equal one man per shift for the furnace and one man per shift for the boiler.

Whichever sulphurous raw material—brimstone, pyrite, blende or others—is consumed in a burner or roaster, the essential object remains the oxidation of the sulphur content to SO_2 suitable for conversion to sulphuric acid. In pyrite roasting, however, the main ancillary functions—to produce a high quality residue and especially to recover heat in the form of process steam—have become decisive factors in determining the ability of pyrites based operations to compete with other forms of sulphur; and hearth furnaces with heat recovery represent a new means to this end.

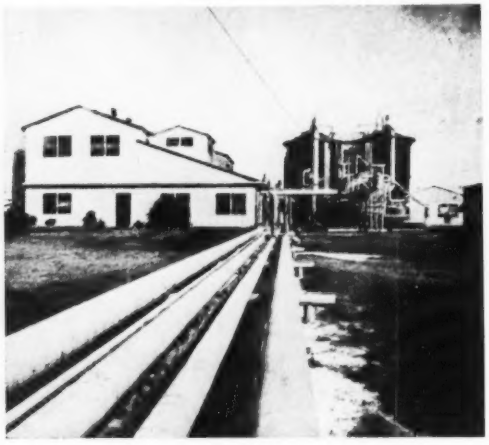
Company Reports

Duval Sulphur and Potash Company

IN HIS REPORT TO SHAREHOLDERS FOR THE YEAR 1958 Mr. W. P. Morris, the President, reviewed the company's established sulphur and potash activities and the prospects, as a result of the diversification into copper. The major factor contributing to the decreased revenue during the year under review was the intense competition in the sulphur and potash markets. Gross revenue declined nearly 10% ($1.3 million) to $12.6 million whilst operating expenses at $9.6 million rose only fractionally. Net income, at $2.6m., compared with 1957, declined 12% ($0.46 million). The new copper project, in addition to the use of the company's own resources and the sale of capital stock ($2.88 million), required recourse to $6 million borrowing under the $8 million bank loan agreement negotiated in 1957.

Company's Activities

Sulphur. The sales of sulphur from the company's Frasch operations at Orchard dome were lower during 1958 than in the previous year*. This decline was the result of the generally depressed business conditions during the year but the effect was lessened by the application of stringent economy measures. Lower production costs per ton of sulphur were achieved despite the fact that 1958 mining operations were carried out in an area which presented difficult operational problems due to the nature of the underground formation. Work was started during the year on the installation of automatic control instruments on boilers in the water heating plant. This installation will be completed early in 1959 and is expected to result in further reductions in operating costs. The company is investigating the possibilities of acquiring additional reserves of sulphur through operating agreements with companies that are prime producers of sulphur bearing gas. The company's sales contract for sulphur and potash with Ashcroft-Wilkinson & Co. was renewed during the year.



Water treating and heating plant showing hot water and compressed air lines leading to the mining area.

Potash. Normal operations at plant capacity were maintained at Carlsbad, New Mexico, where additional facilities to improve the quality of the product were installed. Approximately the same tonnage was sold in 1958 as in the previous year but decreased revenues were due to the decline in sales prices resulting from excess production throughout the world. Exploration near Carlsbad continued in 1958 and there are plans for a drilling programme in 1959 in lands held by the company in the Province of Saskatchewan, Canada, on part of which, after evaluating geological and drilling information, the company relinquished rights, retaining only some 177,000 acres.

Copper. Construction work was nearing completion at the end of 1958 on the copper and molybdenum mining and milling facilities in Pima County, Arizona. Testing operations are in progress and production at a rate of one ton of waste removal to each ton of ore output is due to begin in 1959. The design capacity of the mill is 12,000 tons of ore per day. Arrangements have been made to sell the copper concentrates to a smelting and refining company, whilst an agent has been retained to sell the molybdenum which arises as a co-product.

* See "Sulphur" No. 24, page 14, 148,000 tons.

Gulf Sulphur Corporation

IN PRESENTING HIS FIRST ANNUAL REPORT to shareholders Mr. William Bellano, the newly-elected President of the Gulf Sulphur Corporation, expressed satisfaction with the company's progress during 1958. He stated that in increasing production and shipments by more than 40%, in reducing operating costs and in modifying plant facilities and management, the company has improved its position as an important supplier of elemental sulphur to world markets.

Production and Sales

Production during 1958 amounted to 267,309 tons compared with the 181,255 tons produced in 1957. This increase was due largely to a 20% increase in water capacity to 2.2 million gallons per day, expansion of river transportation facilities and the development of improved mining techniques. It is anticipated that production will exceed 300,000 tons in 1959 and should rise to 350,000 tons in 1960. The company holds between two and three months' stocks of dark and filtered sulphur for immediate delivery to customers.

Shipments in 1958 totalled 279,723 tons compared with the 185,302 tons sold in 1957. 60% of the sales were directed to the United States, whilst the remainder went to Europe, Australia, Israel and the home market in Mexico. In order to obtain more widespread representation in the increasingly competitive world markets Gulf Sulphur entered into a long-term exclusive agency agreement with Continental Ore Corporation of New York. "Effects of this agreement," Mr. Bellano said, "are not expected to be fully felt until 1960."

Finance

Sulphur sales provided an income in excess of $6 million or about $21½ per ton of sulphur sold. Whereas the cost of sales, equalling about $16 per ton, showed a gross margin of about 25%. Selling and administrative expenses of $1.04 million, interest service of $0.3 million and finally provision for depreciation, depletion and amortisation of $0.7 million so reduced this that a net loss of $530,218 resulted. This brings the consolidated deficit on earnings to $2.88 million.

In addition to net income of $172,918 prior to depreciation, depletion and amortisation, funds during the year were provided by the sale of 150,000 shares of common stocks yielding $600,000 and by a decrease in working capital before suspension of debt of $388,058. Apart from lesser payment towards cancellation of long-term debt and net change in the balance of assets and liabilities the bulk of funds was applied to addition to plant and facilities at mine and port amounting to $1.01 million. Deferment and suspension of some financial obligations, primarily vis-à-vis Hudson Engineering Corporation, Hudson Gas & Oil Corporation, Bear Stearns & Company, Delaware Exploration Corporation and Pan American Exploration Company were arranged. The company's total assets less depreciation, depletion and amortisation stand in the books at $8.3 million.

Management

In addition to the appointment of Mr. Bellano as President of the company, two further important appointments were made in 1958. Mr. Luis J. Creel, lawyer, of Mexico City, was appointed President of the Compania de Azufre Veracruz S.A., the company's Mexican operating subsidiary, and Mr. C. J. Brooke, Jnr., was appointed Mines Manager.

Jefferson Lake Sulphur Company

DURING 1958 the operations and activities of the company and its 69% owned subsidiary, Jefferson Lake Petrochemicals of Canada, resulted in a net loss of $659,212. In his message to shareholders and employees, the President, Mr. Eugene H. Walet, Jnr., attributed this to several salient factors as follows: the full impact of the reduced amount received for sulphur due to existing world-wide competitive market conditions; a decline in tonnage sales of sulphur; building of sulphur inventories at the Peace River plant with no

shipments therefrom; a decline in sales and price of products of the Merichem Division; reduction in the allowables for production of oil, particularly in Texas and Louisiana; and an overall increase in operating costs.

Production

The company produced a total of 471,300 long tons of sulphur, including 104,829 long tons extracted from Long Point Dome, for the account of Texas Gulf Sulphur Company. Frasch sulphur operations at the three domes in Texas yielded 398,800 long tons (about 5½% less than in 1957). Recovered sulphur from natural gas in the U.S.A. and Canada accounted for about 15% of total output compared with only 5% in 1957. The Peace River recovery plant, continuing to operate on an efficient basis, has been producing canary yellow sulphur of the highest quality. Since 1958, when the railway link was inaugurated, shipments are moved by rail from the plant site and by barge from facilities located at the Port of Vancouver.

	1958	*1957*	*1956*	*1955*
Long Point Dome	209,100	223,000	246,000	250,000
Clemens Dome ...	99,500	103,000	115,000	124,000
Starks Dome ...	90,200	96,000	93,000	111,000
Manderson, ... Wyoming ...	16,600	17,000	19,000	15,000
Peace River, Canada	55,900	4,800	—	—
	471,300	**443,800**	**473,000**	**500,000**

In the East Calgary field, Alberta, the company has drilled seven wells, six of which are equipped for the production of sour gas. Under the agreement with Mobil Oil of Canada, who have executed their drilling obligations, Jefferson Lake Petrochemicals of Canada Limited are erecting the necessary plant and facilities for the processing of the sour gas to provide for pipeline gas deliveries, recovery of liquid products and the production of sulphur. Drilling activities in the East Calgary field indicate reserves of crude gas with a recoverable sulphur content of 10.1 million tons. The proposed Calgary plant of Jefferson Lake Petrochemicals of Canada Limited will process all this gas and sell the resultant products. The area drilled by the company contains approximately 70% of the proven field reserves of about 1.3 trillion cubic feet.

Sales

Total sales in 1958 amounted to about 433,000 tons, some 30,000 tons (6%) less than in 1957. The company's own sales declined 14% to 328,000 tons, but her sales for the account of Texas Gulf Sulphur Company increased by over a quarter to 104,536 tons. Export sales, which since the 1st July 1958 are being executed by the Sulphur Export Corporation, were destined for Argentina, Australia, Austria, Belgium, Brazil, France, Germany, India, the Netherlands, New Zealand, Poland, Uraguay and Yugoslavia.

Other Activities

Gas and oil operations, which the company conducts in Texas, Louisiana, Oklahoma and Kentucky, expanded during the year.

The Merichem Division, whose main activity is the manufacture of cresylic acid at the Green Bayou plant near Houston, suffered a 42% reduction of sales income, which in the light of production and depreciation charges caused a loss of $107,628.

The development and sales of the Rotasorber, a plant and process which is expected to serve to advantage the gas industry and related fields, was licenced exclusively to the National Tank Company of Tulsa, Oklahoma. At the same time, the company discontinued its own research and development activities on this project.

Finance

Income from all sources during 1958 totalled $11.4 million, a reduction of $3 million (21%) compared with 1957. Of the total, gross sales and income under the company's special mining contract with Texas Gulf represented $9.96 million, similarly about 21% less ($2.52 million) than 1957. Although management succeeded in reducing the cost of sales by about 9% to $8.5 million, gross profit declined by 54% to $1.75 million. Group operating expenses of $2.5 million, of which Jefferson Lake Sulphur Company represented $2.2 million, turned this into a loss of $1.07 m. which was lessened by a tax refund to a net loss of $659,212—a deterioration in results of $1.9 million compared with 1957.

The transfer during the year of all Canadian properties at a net cost of $2.85 million secured 1.4 million shares—69% of the

capital of Jefferson Lake Petrochemicals of Canada Ltd. On the 31st December 1958 this investment was valued on the basis of quotation on the Toronto Stock Exchange at $14.6 million. The company's preferred dividend was maintained at 48c. per share, whereas on common stock the company disbursed U.S. 30c. in cash and 4½% stock dividends, making a total of $1.64 per share based on an average number of shares.

Outlook

Concluding his message, Mr. Eugene H. Walet, Jnr., summed up as follows: "Although the company's earnings continue to be affected by the 'cost price' squeeze, management is confident that the reserve values which have been proven, particularly in Canada, together with the diversified projects now going forward, will result in profitable operations in the future."

The Tharsis Sulphur and Copper Company Limited

PRESENTING THE DIRECTOR'S REPORT AND ACCOUNTS FOR 1958 at the Annual General Meeting on the 14th May, the Chairman and Managing Director, Mr. W. P. Rutherford, commented on the impact of the reduced pyrites market on his company's sales—which contracted 18% thus causing a severe drop in gross income—and on the pyrites industry as a whole, which experienced severe competitive pressure from other sources of sulphur supply, especially Frasch and recovered sulphur. The company's reserves of ore and mining capacity have steadily improved and it is now in the highly satisfactory position of being able to double production to meet any expansion of the pyrites market.

Finance

As the trading profit for the year fell sharply by 45% to £347,050, the net profit declined similarly from £220,234 to £122,728. The company have qualified for treatment as an Overseas Trade Corporation, and this has had the effect of releasing previous provision made for taxation of £100,901. Thus the amount to be carried forward to 1959 was increased by about £28,000 to £228,113, £100,000 was transferred to the general reserve and despite the severe reduction in the company's trading income, it was possible to maintain the dividend for the year 1958 at 12½%.

Pyrites Sales

During 1958 the company shipped to its customers in Spain, the U.K. and Western Europe 568,044 tons, a reduction of about 125,000 tons (18%) compared with 1957. The Chairman attributed this to the recession in European pyrites markets which began three years ago and which was even more marked in 1958. Increasing volumes of Frasch sulphur from Mexico and sulphur recovered from natural gases at the Lacq field in France accentuated the competitive position in sales of elemental sulphur and this affected the sales of pyrites to the extent that at the beginning of 1959 prices once more had to be reduced. In commenting on the company's determination to remain competitive with any sulphur bearing material, Mr. Rutherford was confident of the support of the Spanish Ministry of Commerce and expressed pleasure at the substantial price increases which Señor Planell, the Minister of Industry, had authorised on the 23rd January of this year to apply to deliveries to the controlled Spanish pyrites market. In the light of the changed export market conditions, however, even this enhanced price no longer satisfied. Concluding his general comments on the market, the Chairman drew attention to the technical improvements in the design of modern furnaces permitting steam recovery as a by-product, which should enhance the merits of pyrites as a sulphurous raw material, and to the impact of its metal values. He welcomed the evident signs of improvement during the current year and expressed the hope that this trend would continue.

Mining and Development

The adverse commercial results were to some extent mitigated by increased efficiency, whilst surplus labour was engaged in additional overburden removal at the company's two opencasts. In particular at the Centre Lode, which was started as a small opencast scheme during the year, good progress has been made, and investigations extending to the 5th Floor proved the continuation of cupreous pyrites thus doubling known reserves. Extraction of

Tharsis Sulphur and Copper. Opencast North Lode, looking East to site of new crushing plant.

this high grade of ore is to start later this year on the basis of opencast work to the 5th Floor and underground mining methods of such reserves as may exist below this level. At the North Lode opencast, the mineral storage and crushing installations are now completed. Overburden removal was continued and some mineral was mined. As a proportion of this ore is of cupreous grade, the low cost will help to recompense for the initial outlay in plant and development. To the north-west a large extension of the orebody is indicated. Investigations of the North Lode in depth also confirmed that there is a northern extension of mineral from the present producing mine, Sierra Bullones, and whereas good progress has been made on the main gallery linking the two mines, the final scheme, including the equipping of the North Lode shaft to handle the underground extraction from both mines, will not be finished for some years. At Calañas, the principal operating mine, development of the 18th Floor is now well advanced, and an area of cupreous pyrites in the second ore mass is being investigated.

Transport and Other Services

In view of difficulties experienced with the loading of larger ships, the company welcomes the plans which are being prepared to increase dredging operations of the bar and estuary of the River Odiel. Trends in the pyrites trade and in ship construction make it imperative that Huelva should be capable of accommodating vessels larger than 10,000 tons. The construction and improvements to workers' houses, the building of a new church and other services were important features of the company's social work.

Construction Activities

CHEMIEBAU DR. A. ZIEREN GMBH of Cologne, one of W. Germany's leading plant constructors, reports six new plants completed during 1958 together with an impressive number of new plants on order. The company's operations extend to all European countries, while a large number of works have been built in South and Central America as well as the Far East, including India and Japan.

The most important plants completed during 1958 were the 150 tons per day contact plant for Canadian Industries Ltd., at Beloeil, Quebec, and a sludge acid decomposition plant for Chemische Werke Hüls, near Recklinghausen, W. Germany, with a capacity of 40 tons per day (100% H_2SO_4); the latter unit

Sulphuric acid plant built for Berliner Gaswerke at the Mariendorf coke works, by Chemiebau Dr. Zieren.

supplements the company's existing plant which has a daily capacity of 20 tons and was erected in 1957. Various large-type converter groups including heat exchanger, as well as H_2S combustion plants were built for some well-known companies.

Thanks to rapid construction work in 1958 four plants were commissioned early in 1959. The largest is the 100 tons per day unit at Eaglescliffe, Co. Durham, which, built by the Power-Gas Corporation, is now in regular operation. In India four plants have been commissioned with daily capacities of 25-160 tons, while in Chile the company installed a 15 tons per day contact plant based on sludge acids.

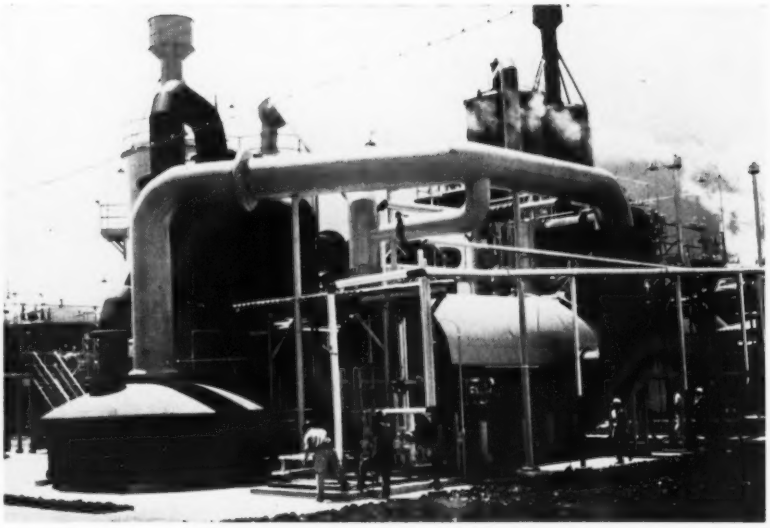
Engineering work is progressing satisfactorily on a number of projects, notably in Spain, but also in India and Japan, while in Germany the plant for Glanzstoff-Courtaulds GmbH at Cologne, with a daily capacity of 150 tons is now expected to be completed at the end of this year. In Spain the company is engaged upon various sulphuric acid plants with capacities ranging from 100 to 250 tons per day based on the use of SO_2 in the exit gases of sulphide ore smelters.

Recently the company obtained an order from Yugoslavia for the erection a 155 tons per day contact sulphuric acid plant based on pyrites concentrates which is at present being designed. It is believed that civil engineering work will start at the end of this year.

Chemical Construction Corporation

IN 1958 CHEMICO commissioned five sulphuric acid plants in different parts of the world. Two of these were built in the U.S.A.—the plant for American Cyanamid Corp. at Savannah, Ga., has a daily capacity of 250 tons (100% H_2SO_4) and that for the National Lead Corp. at St. Louis, Mo., 350 tons per day—bringing the company's total to over ninety plants constructed in that country since 1927. Apart from these two units the largest was a 150 tons per day plant built for Hall, Longmore & Co., acting for Buffelsfontein Gold Mining Company of Johannesburg, South Africa, a member of the Anglo-Transvaal Consolidated Investment Co. Ltd. The sulphuric acid manufacture is based on pyrites concentrates recovered by flotation from gold ore slimes from which subsequently the small quantity of uranium oxide—about 2lbs. per ton—is leached by means of sulphuric acid. Plants built for Hidro Nitro Espanola and the Anaconda Company in Chile both with daily capacities of 75 tons completed Chemico's 1958 construction programme.

In addition to work progressing on a 100 tons per day expansion to the Buffelsfontein plant, Chemico is building five new units during this year. Three are for companies in the U.S.A.*, one for Lago Oil and Transport Company at Aruba in the Dutch West Indies with a daily capacity of 215 tons (100% H_2SO_4) based on spent acid, and the last is a 180 tons per day plant for the Befu Chemical Company in Japan.



Guanos y Fertilzantes. The new 150 tons per day plant completed in 1958 by Pan-American Consulting Inc.

Leonard Construction Company

DURING 1958 the Leonard Construction Company of Chicago, Illinois, a wholly owned subsidiary of Monsanto Chemical Company, added six more sulphuric acid plants to the impressive total of over 150 units already installed by them for companies throughout the world. Five of the new plants were constructed in the United States* and the sixth was built for Canadian Industries Ltd. at Copper Cliff, Ontario, Canada. Leonard Construction Company also installed further capacity for Lorado Uranium Mines of Beaverlodge, Canada, who, as a result, now have facilities for the daily production of 90 tons 100% H_2SO_4.

Included in the construction programme for 1959 are three projects which are of exceptional interest on account of their location, size and end use of acid. One of the largest plants in the world is the 1,350 tons per day unit being built for Freeport Nickel Company in Cuba to leach lateritic nickel ores. At Point Lissas in Trinidad a 190 tons per day plant is under construction for Federation Chemicals Ltd., for the production of ammonium sulphate, whilst a 350 tons per day unit is being erected for J. R. Simplot Company of Pocatello, Idaho, in conjunction with their phosphatic fertilizer project.

Pan American Consulting Co. Inc.

THE Pan American Consulting Company Inc., of Reisterstown, Maryland, reports the completion of seven sulphuric acid plants in 1958 with a daily capacity of 370 metric tons (100% H_2SO_4) and progress on a further four plants now under construction with a total daily capacity of 250 tons.

The company, whose construction activities are centred principally in Central and South America and the Far East, specializes in plants of the Conpan-Monsanto design employing Monsanto vanadium catalyst. The largest plant completed in 1958 was the 150 tons (100% H_2SO_4) per day unit for Guanos y Fertilizantes de Mexico S.A. at Cuautitlan, Mexico, and is located next to the existing 180 tons per day brimstone burning plant, completed in 1951. It is reported that both these plants are frequently operated at 20% in excess of their rated capacity. The following table indicates particulars of other new plants completed during 1958 :—

* For further details see page 16

Company	Location	Country	Capacity Metric tons per day 100% H_2SO_4
Cia. Quimica Industrial "Quin" S.A.	Cali	Columbia	30
Rayon Peruana S.A.	Lima	Peru	25
Productos Quimicos "Elekeiroz" S.A.	Sao Paulo	Brazil	50
Quimica Industrial Brasileira S.A.	Sao Paulo	Brazil	100
Samu Sulphuric Acid Manufacturing Co. ...	Tongnae	Korea	15
Indurayon Consolidada S.A.	Barranquilla	Colombia	20

The projects under construction include a 150-ton per day installation in Mexico for Guanos y Fertilizantes de Mexico S.A. at Coatzacoalcos, similar to the one already built by Pan-American Consulting Company at Cuautitlan; two 25-ton per day plants in India for the Juggilal Kamlapat Cotton Spinning & Weaving Mills Co. (Pvt.) Ltd., at Kanpur, and for Atul Products Limited at Bulsar, and one in Peru. The latter, a 50-ton per day unit for Industrias Quimica Basicas S.A. at Lima, has just been completed and is now on stream.

Current Events

AUSTRALIA

First Brimstone Production

The new 40 tons per day elemental sulphur recovery plant at the Altona works of the *Standard Vacuum Refining Company (Australia) Ltd.*, came on stream in July. The plant was built by Power-Gas (Australasia) Pty. Ltd., and was designed in association with the Dutch concern, Comprimo N.V., who are under licence to N.V. de Bataafsche Petroleum Mij. The recovery of the sulphur content of hydrogen sulphide in refinery gases is by a modified two-stage Claus kiln embodying features to give a rate of sulphur recovery in excess of 95%. The gases finally pass through a third catalytic bed in which almost all the remaining hydrogen sulphide and sulphur dioxide yield a small amount of elemental sulphur and water. The hydrogen sulphide content of the residual gases is less than 5 ppm., minimizing atmospheric polution. This is the first production of elemental sulphur in Australia: at the Geelong oil refinery, the sulphur content of the refinery gases, which is in the form of H_2S, is converted directly to sulphuric acid.

CANADA

Wet Phosphoric Acid

A change of plan is reported in connection with the important phosphoric acid and phosphorus derivatives project of the *Electric Reduction Company of Canada.* Originally the company, a subsidiary of Albright and Wilson Ltd., intended to build itself a sulphuric acid plant at Port Maitland in Ontario and to use the sulphuric acid for making phosphoric acid by the wet process. It was intended to start production early in 1960. Now, however, the company has signed an agreement with the Matthieson and Hegeler Company of La Salle, Illinois, for the purchase of sulphuric acid. This will be made as a by-product at a new zinc smelter to be built by the Sherbrooke Metallurgical Company Ltd., a newly-formed subsidiary of Matthieson and Hegeler. The sulphuric acid plant and smelter will be near the new works which Electric Reduction plans at Port Maitland. When the scheme is finally completed, Electric Reduction Co. will have the only wet process phosphoric acid plant in Eastern Canada.

Some of the phosphoric acid is to be used for making calcium and sodium phosphates and some will go for industrial uses such as treating steel and aluminium. Nevertheless it is expected that a considerable quantity will be made available to Dominion Fertilizers Ltd., which has recently been acquired by the Electric Reduction Company. The demand in Eastern Canada for fertilizers is rapidly rising; and it seems likely that Dominion Fertilizers, which at the moment produces superphosphates, may in future go on to make triple superphosphates or complex fertilizers.

UNION OF SOUTH AFRICA

Standard Vacuum Oil Company

The installation of a 33 tons per day sulphur recovery plant completes *Standard Vacuum Oil Company's* expansion at their oil refinery at Durban, where daily capacity was

General view of the Durban refinery. Sulphur recovery plant on right, D.E.A. unit on right and hydrofiner in background.

increased from 21,000 barrels to 26,000 barrels last December. Since coming on stream on 23rd January, 1959, operations at the sulphur plant have progressed satisfactorily although, due to the shortage of hydrogen sulphide only 25% of capacity was used. The plant, which is based upon the Claus principle, was designed by Esso Research technicians and built by Foster Wheeler Ltd. The entire sulphur output is sold to the South African Industrial Cellulose Corporation Ltd. (SAICCOR) for consumption at their viscose plant at Umkomaas in Natal.

New Fertilizer Plant

Fisons (Pty.) Ltd., jointly owned by N.V. Albatros Superfosfaat Fabrieken of Holland and by Fisons Limited, has now completed work on the £2¼ million fertilizer works at Sasolburg in the Orange Free State; and the opening ceremony took place on the 31st July. The new plant is to produce 200,000 tons of superphosphates and 112,000 tons of granulated compound fertilizers annually. The scheme includes a sulphuric acid plant with a capacity of 230 tons a day (100% H_2SO_4), which was constructed by Simon Carves. Some of the acid is consumed by the company's superphosphate plant, and some goes to the nearby works of the South African Coal Oil and Gas Corporation. Here sulphuric acid is used for treating the weak ammonia liquor that arises as a by-product in the extraction of oil and gas from coal. Acid from Fisons (Pty.) Ltd. will account for a considerable portion of the total consumed; and most of the resulting ammonium sulphate is in turn to be supplied to Fisons (Pty.) Ltd. for their various compound fertilizers. The siting of the Sasolburg fertilizer works in the centre of the great maize belt is intended to permit quicker deliveries to maize producers than are possible from the company's two older works at Durban and at Kuils River in Cape Province.

TRINIDAD

Sulphur Production

During 1958 *Texaco*, who at Pointe-à-Pierre own and operate Trinidad's largest oil refinery, produced 4,900 tons of brimstone. Total output was used for acid manufacture which reached to 15,600 tons. The company operate two acid plants, one of which is a stand-by unit. The plant normally in operation is an acid regeneration unit built to the Chemico design, while the other plant was built to Monsanto design. Sulphuric acid production is captively consumed in refinery operations and a very small quantity is sold on the island for local uses. The recent announcement of Texaco to double the daily capacity of their refinery from 125,000 barrels to one-quarter million barrels, will in no way affect sulphur recovery operations and production is expected to continue at a level of about 20 tons per day

from a plant which has a daily capacity to produce 30 tons high purity brimstone in the form of pellets. This is the only plant in the world where sulphur is produced in this form and the process involves molten sulphur being dropped into water from a tower some 60 feet high.

UNITED STATES OF AMERICA

Tidewater's New Gas Processing Plant

Following an extensive period of pilot plant trials carried out to solve the problems presented by the complex composition of the gas at New Hope in Texas, *Tidewater Oil Company* of Delaware have announced the imminent construction of a plant capable of processing 50 million c.f. gas per day. The plant, which is designed to work at a pressure of 1,800lb. p.s.i.g. will produce daily 7,480 barrels of 64 gravity distillate, 1,040 barrels of propane and 550 barrels of butane. In addition, facilities for the daily recovery of 224 tons of pure sulphur are being incorporated.

Apart from a modest holding by a number of other companies, Tidewater Oil Company and Texaco Inc. each have 46% interest in the New Hope plant which is to be constructed by the Hudson Engineering Corporation. These facilities are the second of Tidewater's sulphur ventures and, when completed, will establish the company as the largest producer of recovered brimstone in the United States of America. The recovery plant at their Delaware refinery has been operating at a level in excess of its daily rated capacity of 342 tons high purity brimstone.

Sulphuric Acid for Uranium Leaching

The new 3,630 tons per day uranium mill at Ambrosia Lake in New Mexico, owned by the *Kermac Nuclear Fuel Corporation*, started production on November 28th of last year. Its sulphuric acid plant, built by the Leonard Construction Company under contract to the Western Knapp Engineering Company, is the largest acid plant integrated with a uranium mill. The plant's normal rated capacity is 400 tons of 100% sulphuric acid a day, but it can produce daily about 50 tons more than this. Automation has been carried so far that the entire sulphuric acid plant is operated by only two men. Raw material is in the form of molten recovered sulphur, which is transported in special trucks from the oil refineries in western Texas. The plant's production exceeds the joint requirements of the company's uranium mills at Lake Ambrosia and at Shiprock, also in New Mexico; and the surplus sulphuric acid is sold to other uranium oxide producers in the area.

ITALY

New By-product Acid Plant

Industria Raffinazione Oli Minerali S.p.A., a subsidiary of British Petroleum Ltd., plan to commission a new sulphuric acid installation at Porto Marghera (Venice) in August. Hydrogen sulphide will be obtained from a gas oil hydrofiner which has a capacity to treat 6,500 barrels per day and will reduce the sulphur content of the oil from 1.3% to 0.1% maximum by weight. The acid gas will be converted in a De Nora-Monsanto sulphuric acid plant with a daily capacity of 25 tonnes (100% H_2SO_4). Designed and constructed by Oronzio de Nora of Milan, the convertor section employs a vanadium catalyst. Sulphuric acid production will be used, in part, at the refinery, although not for alkylation purposes, and for sale to local consumers.

WEST GERMANY

Rubber Sulphurs

Stauffer Chemical Company and Kali-Chemie A.G. are negotiating an agreement to form a joint company to produce and market a special insoluble sulphur in Western Europe. The company, to be known as Kali-Chemie-Stauffer GmbH, plans to build a plant at Hanover, Germany, which it is anticipated, will be in production by January 1960. Output of the new facilities will be marketed by Kali-Chemie A.G. under the trade name "Crystex."

Kali-Chemie A.G. operates fifteen plants in West Germany and is a major manufacturer of chemicals and fertilizers, notably superphosphates. The company's sulphur activities comprise the recovery of some 5,000 tons per annum high purity brimstone and the manufacture of about 10,000 tons sulphuric acid from pyrites. The arrangement with Stauffer will be mutually advantageous and will bring to the Continent the know-how of U.S. manufacture of rubber-makers sulphur, amongst which Stauffer " Crystex " is prominent.

SPAIN

Elemental Sulphur Production 1958

Sulphur production in 1958 at 47,009 tonnes was maintained at a level slightly lower than in the previous year when output was 47,541 tonnes. The principal event in the industry was the closure in 1957 of the refining plant of Azufres de Lorca S.A. based on native ores so that in 1958 the only producer in this sector of the industry was Coto Minero de Hellin. Located at Hellin, Albacete, the company's production totalled 2,715 tonnes compared with 2,574 tonnes in 1957. Production by Cia Española Minas Rio Tinto S.A. at Rio Tinto, Huelva, was 35,900 tonnes elemental sulphur, a reduction of 300 tonnes compared with the previous year, while Real Cia Asturiana de Minas, whose process is based on the reduction of SO_2 by the ASARCO process, increased by 500 tonnes to 8,394 tonnes.

Despite a high internal price and support by subsidies, recent years have seen the closure of several sulphur ore refining plants. Lean ores, high costs of refining and overheads accentuated by the small size of operation, were the main factors which were not relieved by the abundance and cheapness of world brimstone supplies. The present level of sulphur production in Spain is not sufficient to meet her domestic requirements; imports total about 5.000 tonnes into Metropolitan Spain and a similar amount into the Canary Islands.

SWEDEN

Stora Kopparbergs Bergslags Aktiebolag

One of the country's two pyrites producers, the company is Sweden's oldest industrial enterprise whose regular copper mining activities date from the 13th century. To-day their interests cover mining of ferrous and non-ferrous metal ores, forest industries, water power, farming and chemical products.

In 1958 the company's output of sulphuric acid, based upon pyrites concentrates produced from captive ore mining activities, rose once more. The plants located at Falu Kopparverk and Skutskar produced 54,777 tons of 100% H_2SO_4, representing an increase of 4½% over 1957. Pyrites concentrates output also rose and at 52,087 tons (46% S), showed an advance of 2½% over the previous year. Contrary to other companies activities, pulp production of 98,040 tons, which represented a fractional decline as compared with 1957, was not severely affected by Sweden's recession in the pulp industry.

During the year Stora Kopparberg's A.B. made a bonus issue of Kr.75 million (£5.17 million) which brought their total share capital to Kr.225 million (£15.52 million). Although the 1958 profit of approximately Kr.32 million (£2.2 million) was Kr.5.5 million (£450,000) less than in 1957, the company paid the 15% dividend which has been operative without change since 1953.

EGYPT

New Sulphuric Acid Facilities

Société Misr pour la Rayonne of Kafr El-Dawar who are the largest producers of rayon in Egypt, have added to their facilities a second sulphuric acid plant of the same design and in 1949 by Simon Carves Ltd. of Cheadle Heath. This plant, which has a capacity of 30 tons (100% H_2SO_4) daily uses 10 tons of recovered sulphur supplied by Anglo Egyptian Oil Fields from their oil refinery at Alexandria. Heat recovered from the sulphur burner is used in the manufacturing process which yields 37 tons of rayon daily. The plant, on which construction work commenced in May of this year, is due to be commissioned on the 1st September 1959.

IRAQ

No Sulphur Development

Contrary to various Press reports there is no foundation that negotiations have been resumed between Texas Gulf Sulphur Company and the Iraqi Government concerning the exploitation of the country's sulphur resources. Following the identification of a sulphur dome near Kaiyara in northern Iraq, Texas Gulf Sulphur Co. had conducted protracted discussions with the Iraqi Government about four years ago, when, due to the lack of agreement, talks ceased. Since then, the management of Texas Gulf Sulphur Co. confirms that no further practical interest has been shown.

Statistical Appendix

United States

		PRODUCTION		STOCKS		EXPORTS	IMPORTS*
		Frasch	Recovered	Frasch	Recovered		
1955		5,743,344	401,650	3,181,198	110,591	1,595,423	38,317
1956		6,427,229	480,980	3,936,450	119,446	1,651,597	203,044
1957		5,491,210	519,078	4,422,548	157,075	1,561,093	484,680
1958		4,644,812	619,594	4,442,066	177,271	1,567,072	582,659
1958	January	461,285	54,198	4,540,198	161,379	87,430	35,919
	February	415,186	49,699	4,620,606	163,817	103,376	45,422
	March	429,475	51,786	4,620,947	163,512	127,713	48,979
	April	402,581	46,340	4,638,320	165,399	144,117	20,072
	May	415,115	50,016	4,620,347	168,273	137,350	48,235
	June	383,664	48,662	4,661,649	160,946	167,949	27,875
	July	359,384	47,796	4,721,167	165,612	102,114	64,505
	August	355,639	50,932	4,665,598	168,844	149,391	61,250
	September	335,823	51,709	4,652,199	172,446	122,813	47,160
	October	347,838	53,260	4,529,737	171,470	168,755	68,181
	November	360,378	52,916	4,462,475	172,050	142,641	37,668
	December	378,444	62,280	4,442,066	177,271	113,423	73,789
1959	January	346,475	52,284	4,426,613	180,388	67,031	33,809
	February	317,696	54,295	4,375,557	177,902	123,269	53,447
	March	373,599	58,546	4,325,410	177,527	87,523	43,228

* Imports of sulphur from Mexico only.

Official Bureau of Mines Data (long tons of 2,240lbs.)

SULPHUR EXPORTS

Long Tons

	1st Qtr. 1959	*1st Qtr. 1958*		*1st Qtr. 1959*	*1st Qtr. 1958*
Canada	17,488	30,913	Switzerland	—	1,700
N. Antilles	5,000	2,500	Yugoslavia	2,000	—
Argentine	1,912	984	Israel	5,000	—
Brazil	42,554	21,134	Syria	49	—
Columbia	108	—	Algeria	5,000	4,860
Cuba	3,310	—	Tunisia	2,000	—
Guatemala	50	50	Lebanon	1,000	1,500
Paraguay	97	—	Iran	—	3,000
Peru	1,009	—	Bahrain	203	—
Uruguay	181	1,741	S. Arabia	546	—
Venezuela	598	396	Canary Isles	1,968	—
Costa Rica	—	22	India	21,310	31,750
United Kingdom	44,265	54,485	Indonesia	2,700	1,000
Belgium	9,400	23,350	Pakistan	—	295
France	30,220	37,790	Un. of S. Africa	15,450	16,500
Austria	2,000	10,000	Korean Rep.	—	229
W. Germany	14,250	12,320	Philippines	—	47
Poland	4,000	2,500	New Zealand	16,683	12,204
Netherlands	—	5,250	Australia	27,675	41,999
			Total	**278,026**	**318,519**

Mexico

		Pan-American Sulphur Co.	*Gulf Sulphur Corporation*	*PEMEX and Texas Gulf Sulphur*	*Negociacion Minera de Azufre SA*	*Total*
1958	March	73,743	21,945	10,721	1,500	107,909
	April	70,235	20,800	11,500	1,500	104,035
	May	78,221	18,983	11,777	1,575	110,556
	June	60,726	26,605	11,999	1,500	100,830
	July	54,843	27,664	12,500	1,500	96,507
	August	71,943	24,790	12,075	1,450	110,258
	September	67,943	23,482	14,695	1,100	106,990
	October	70,984	21,532	14,800	1,360	108,676
	November	72,981	23,316	15,000	1,400	112,697
	December	74,794	24,033	14,975	1,520	115,322
1959	January	66,862	23,004	14,500	1,400	105,766
	February	67,184	24,424	14,060	1,422	107,090
	March	72,941	26,620	15,620	1,500	116,681
	April	63,188	25,237	15,000	1,500	104,925
	May	69,140	23,093	15,200	1,591	109,024
	June	73,166	25,144	14,500	1,500	114,310

France

SULPHUR EXPORTS 1958

Metric Tons

Countries	*January*	*February*	*March*	*April*	*May*	*June*	*Total*
Great Britain ...	6,644	3,325	2,900	2,819	4,776	8,231	28,695
Germany	3,026	2,294	2,700	596	2,573	812	12,001
Belgium	3,959	2,036	—	3,877	1,948	3,185	15,005
Greece	—	782	—	—	—	—	782
Poland	—	1,096	—	—	—	—	1,096
Switzerland	23	23	—	—	—	6,629	6,675
Finland	1,049	—	—	2,158	—	—	3,207
Austria	—	—	3,353	—	1,853	—	5,206
Israel	—	—	1,006	—	—	—	1,006
Holland	—	—	—	—	2,414	—	2,414
Denmark	—	—	—	—	—	1,118	1,118
Portugal	—	—	—	—	—	300	300
							77,505

PYRITES EXPORTS 1958

Thousand Metric Tons

	Spain	**Cyprus**	**Norway**	**Portugal**	**Yugoslavia**	**Greece**
Algeria	10.5	—	—	2.1	—	—
Austria	18.5	—	—	—	7.1	11.3
Belgium	87.5	52.9	—	111.6	—	—
Czechoslovakia ...	—	—	21.2	—	49.0	25.4
Denmark	83.6	—	45.6	—	—	—
Eire	23.7	—	—	1.9	36.2	—
Egypt	56.8	—	—	—	—	—
France	201.6	187.0	11.0	50.3	—	—
East Germany ...	—	—	41.6	—	—	—
West Germany ...	516.2	289.2	155.0	64.2	64.6	9.7
Hungary	—	—	—	—	29.0	—
Italy	31.8	130.7	—	—	41.6	14.8
Morrocco	—	—	—	1.5	—	—
Netherlands ...	12.7	244.9	10.4	116.2	—	14.1
Poland	5.6	—	—	—	50.9	5.0
Sweden	—	—	103.8	—	—	—
United Kingdom ..	53.1	149.3	—	3.6	—	—
Other	28.9	—	6.3	6.2	—	—
Total 1958 ...	**1,130.5**	**1,065.4**	**394.8**	**357.4**	**279.3**	**80.4**
Total: 1957 ...	**1,445.9**	**1,004.7**	**449.7**	**297.0**	**193.0**	**186.8**

Cyprus

PYRITES EXPORTS

Long Tons

IRON PYRITES	*Jan.-June 1959*	*Jan.-June 1958*	**CUPREOUS PYRITES**	*Jan.-June 1959*	*Jan.-June 1958*
United Kingdom	67,060	64,709	Belgium	3,445	—
Belgium	27,224	25,299	W. Germany	31,707	16,870
France	105,796	102,733	Italy	27,867	36,035
W. Germany	87,528	110,987	Netherlands	86,430	62,232
Italy	21,356	39,547			
Netherlands	69,046	54,045	**Total**	**149,449**	**115,137**
Total	**378,010**	**397,320**			

Portugal

PYRITES EXPORTS

Metric Tons

	Jan.-May 1959	*Jan.-May 1958*			
Tunisia	4,075	3,100	Netherlands	40,410	41,200
United Kingdom	—	720	Algeria	—	2,050
W. Germany	34,713	29,036	Ireland	1,738	—
Belgium	64,758	40,275			
France	29,924	14,200	**Total**	**175,618**	**130,481**

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